

























Eighty-first Annual Report  
of the  
**Entomological Society**  
of Ontario

**1950**

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Minister of Agriculture



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1951



Eighty-four Annual Report

of the

Entomological Society

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1950



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OCT 25 1951



# Entomological Society of Ontario



## OFFICERS FOR 1950-51

*President:* W. N. KEENAN, Ottawa, Ontario.

*Vice-President:* G. F. MANSON, Chatham, Ontario.

*Secretary-Treasurer:* R. H. OZBURN, Guelph, Ontario.

*Editor (of Annual Report):* W. E. HEMING, Guelph, Ontario.

*Directors:* W. N. KEENAN, Ottawa, Ontario; J. McB. CAMERON, Sault Ste. Marie, Ontario;  
H. W. GOBLE, Guelph, Ontario; A. W. A. BROWN, London, Ontario; D. P. PIELOU,  
Belleville, Ontario; G. F. MANSON, Chatham, Ontario; R. GLEN, Ottawa, Ontario;  
G. E. BUCHER, Kingston, Ontario; W. G. GARLICK, Vineland Station, Ontario.

*Representative to Directorate of Entomological Society of Canada:* W. N. KEENAN, Ottawa, Ont.

*Auditors:* To be appointed by the President and Secretary.

*Committee on Constitution:* To be appointed by the President.

## FINANCIAL STATEMENT

for

YEAR ENDING OCTOBER 31, 1950

*Receipts*

Dues .....	\$ 925.25
Subscriptions .....	1,058.80
Reprints .....	598.07
Back Numbers .....	97.64
Cuts .....	83.18
Advertising .....	171.13
Miscellaneous (Gov't Grant, Bank Exchange, etc.) .....	344.12
	<hr/>
	\$3,278.19

Bank Balance,  
31 Oct., '49 .....\$2,448.93

Less cheques  
outstanding ..... 805.00

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\$1,643.93

Cash on hand,  
31 Oct., '49 ..... 7.33

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\$1,651.26

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\$4,929.35

=====

*Asset*

Bond .....	\$ 400.00
Unclipped Coupons .....	12.00

Audited and found correct,  
30 October, 1950.

R. C. COOKE

C. J. PAYTON

*Expenditures*

Printing The Can. Ent. ....	\$2,793.00
Postage for Can. Ent. ....	180.93
Reprints .....	719.24
Cuts .....	292.72
Express .....	32.40
Miscellaneous (postage, stationery and supplies, library, bank exchange, etc.) .....	484.29
Honoraria .....	175.00
	<hr/>
	\$4677.58

Less outstanding cheques ..... 876.85

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\$3,800.73

Bank Balance, 31 Oct., '50 ..... 1,128.62

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\$4,929.35

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R. H. OZBURN,

*Secretary-Treasurer.*

To:

*Outstanding Commitment:*

Publishing The Canadian Entomologist July-Dec., 1950 .....	\$1,500.00
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## REPORT OF COUNCIL, 1950

A meeting of the Council of the Entomological Society of Ontario was held in the Faculty Lounge, Ontario Agricultural College, 31 October at 7:30 P.M.

*Present:* Mr. W. N. Keenan, President; Dr. W. R. Thompson, Editor; Messrs. R. E. Balch, A. W. Farstad, C. A. S. Smith, A. W. Baker, B. N. Smallman, J. Rempel, A. B. Baird; and by invitation, Dr. R. Glen and Dr. A. P. Arnason.

*Financial Statement:* The financial statement was read by the Secretary-Treasurer, who, on the motion of Prof. Baker and Dr. Rempel, was instructed to show at the bottom of the statement as an outstanding commitment the cost of publishing the remaining five numbers of the 1949-50 volume of the journal, the cost to be based on the average cost of the numbers published in the current fiscal year.

*Commercial Exhibits:* The Council approved commercial exhibits at the annual meetings, but details, including charges, if any, for exhibit space were left to the discretion of the local committee in charge.

*The Entomological Society of Canada:* Mr. Ross outlined the developments and progress to date in connection with the formation of the national entomological society, and suggested that such a society should be created without undue delay. Its chief functions should be:

- (1) to publish The Canadian Entomologist jointly with the Entomological Society of Ontario;
- (2) to serve as a national society and as the parent association of, or as the link between, the other entomological societies in Canada. It was stressed that each regional society would be autonomous, could publish its own publication or annual report, and would not lose its identity;
- (3) to encourage the organization of additional provincial or regional entomological societies in Canada;
- (4) that the annual meeting of the Entomological Society of Canada should always be held jointly with the annual meeting of one of the regional societies;
- (5) that the fee for 1951 shall be \$4.00 for direct membership, and \$3.00 for members of a regional society;
- (6) that the Entomological Society of Ontario should hereafter operate as a regional society;
- (7) that the Entomological Society of Ontario should be jointly responsible with the Entomological Society of Canada for the publication of The Canadian Entomologist. (The Entomological Society of Ontario founded The Canadian Entomologist and has been responsible for its publication for eighty-one years.)
- (8) that the Entomological Society of Ontario should continue to issue the Annual Report of the Entomological Society of Ontario. This Report, which is published by the Ontario Department of Agriculture, serves as a valuable outlet for entomological papers;
- (9) that the library of the Entomological Society of Ontario should be available to all members of the Entomological Society of Canada, but that it should remain at Guelph, as the property of the Entomological Society of Ontario; that publications received in exchange for The Canadian Entomologist should be filed as in the past, in the library of the Entomological Society of Ontario.

A formal motion that the national society be formed, and that a Board of Directors should consist of nine individuals representative of the membership in Canada and including the president or other elected representative of each regional society, was approved.

It was decided to hold the 1951 annual meeting in Ottawa early in November, in conjunction with the first meeting of the Entomological Society of Canada.

R. H. OZBURN

Secretary-Treasurer

## USE OF RADIO-ACTIVE TRACERS IN INVESTIGATIONS ON SOIL-INHABITING INSECTS<sup>1</sup>

R. A. FULLER<sup>2</sup>, J. W. T. SPINKS<sup>3</sup>, A. P. ARNASON<sup>4</sup>, and H. McDONALD<sup>5</sup>

*Dominion Entomological Laboratory and University of Saskatchewan  
Saskatoon, Sask.*

### INTRODUCTION

The use of radio-active isotopes in biochemical and physiological research for the tagging of molecules is now well known and widely employed. However, many of these newly available nuclides can also be used to advantage in determining the positions and tracing the movements of whole animals. By attaching harmless amounts of radio-active materials to animals, many types of ecological and behaviour studies can be carried out.

Two types of experiment in which whole animals are tagged should be distinguished. In the first, large numbers of an animal population are marked and released for subsequent recognition, as in insect dispersal studies. In the second, individual animals such as insects are tagged in order to follow their movements under natural conditions.

The choice of the isotope to be used depends upon which of these types of study is to be carried out. In the first case the following points should be considered: (a) ease of application to large populations; (b) minimal manipulation, preferably none at all; (c) ease of recognition of marked specimens (even without killing them when this is desired); (d) certainty of persistence of marking throughout the life of the animal; and (e) freedom from deleterious biological influences.

In this paper, we are concerned with the second type of study, and here two considerations are of primary importance: (a) the distance at which a given tag can be reliably detected by available instruments and (b) the maximum permissible radioactivity that may be applied without any danger of radiation injury either to the tagged animal or the experimenter.

For either type of study it is obvious that the half-life of the isotope is an important consideration (the *half-life* is the time it takes for the activity of a given amount of radio-active material to decrease to one-half of its original value). When the half-life is short, the permissible amount of initial radio-activity is greater, together with the practical range of detection. In addition, the shorter the half-life, the safer is the isotope for this type of work, because it will become harmless sooner no matter where it is carried.

The work to be described in this paper was begun at the Dominion Entomological Laboratory at Saskatoon and was then organized as a co-operative project between Science Service, Canada Department of Agriculture, and the Department of Chemistry of the University of Saskatchewan, with a special financial contribution for this purpose from the Department of Agriculture. Radio-active  $\text{Co}^{60}$  was chosen for the work because its comparatively high-

<sup>1</sup>Contribution No. 2770, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada; in co-operation with the Department of Chemistry, University of Saskatchewan. Presented as an invitation paper at the 81st Annual Meeting of the Entomological Society of Ontario, November 1, 1950.

<sup>2</sup>Agricultural Research Officer, Dominion Entomological Laboratory, Saskatoon.

<sup>3</sup>Head, Department of Chemistry, University of Saskatchewan.

<sup>4</sup>Officer-in-Charge, Dominion Entomological Laboratory, Saskatoon.

<sup>5</sup>Agricultural Research Officer, Dominion Entomological Laboratory, Saskatoon.



energy gamma radiation makes detection possible through several inches of soil and because its long half-life minimizes corrections for decay. The insects studied were slow-moving and unlikely to be lost under the experimental conditions used, so that an isotope with a long half-life could be employed without much danger. The radioactive cobalt was obtained in the form of small pieces of wire, 1.0 mm. in length, 0.250 mm. in diameter, and 0.5 mg. in weight. Each of the 30 pieces used had an initial activity of about 0.022 millicuries.

Three species of soil-inhabiting insects have been studied with  $\text{Co}^{60}$  tags. The larvae of the prairie grain wireworm, *Ctenicera aeripennis destructor* (Brown); the red-backed cutworm, *Euxoa ochrogaster* (Guen.); and the pale western cutworm, *Agrotis orthogonia* (Morr.), spend a great deal of their time beneath the soil surface. In fact, the wireworms almost never appear above the soil surface and the cutworms surface only at infrequent intervals. Radio-active tagging of these insects offers a means of studying their behaviour while in the soil.

### METHODS OF STUDY

Because the method of applying the radioactive material to the test insect is the first problem in such a study and because it has resulted in some interesting observations, it is well to discuss this problem briefly. Feeding activity to the larvae as a means of making them radioactive is not feasible for many reasons, so that the radio-active cobalt tag has been applied in two ways: by external attachment and by internal insertion.

Wireworms were the first insects to be studied, and a great many materials were tested for attaching radio-active cobalt wire pieces to them. The cobalt was placed in the caudal notch of the larvae and attachment was made to the ninth segment and the urogomphi. A fast-drying, acetone-soluble cement was found to be most satisfactory for this purpose. A small drop of the cement was placed on the urogomphi and the ninth segment. Before the cement had completely dried the cobalt piece was placed on it. With a camel's-hair brush dipped in acetone, the metal was arranged so as not to protrude and the cement was smoothed out. Only on infrequent occasions did larvae treated in this way lose their tags without moulting.

The larvae were watched for any effects of the radiation or of the methods used in attaching the cobalt. The activity (0.022 mc.) had little, if any, effect on larvae that had activity attached to them for periods up to three months. Some of the treated larvae died, but in no higher numbers than normally reared laboratory specimens.

Most of the larvae treated externally with radio-cobalt were reared until they shed the activity by moulting. Many of these, after moulting, showed the absence of the urogomphi as recognizable structures. Some grooves were apparent in the ninth segment as if the urogomphi had been incorporated into it. Rearing of these larvae has been continued and recently a few specimens have again moulted. The urogomphi have not reappeared in any of the specimens so far.

Inactive wire was attached with the same cement to a series of ten larvae to study the effect it may have when the larvae moult. Four of the larvae have moulted and none has lost the urogomphi. More results are necessary before it will be established whether the loss of the urogomphi is due to effects of the radio-activity or to a mechanical blocking of the moulting process.

External application is suitable only between moults, for the activity is shed at each ecdysis. To avoid this loss of activity at each moult and thus permit observations over an extended period, experiments were carried out to investigate the possibility of inserting cobalt wire into the body cavity of the larvae. Before the wire was available from Chalk River, both silver and platinum wire (non-radio-active) were used to see whether the surgical shock or presence of the foreign body would be lethal.

There was a high survival rate in these experiments; and it was therefore assumed that, provided the insertion was done properly, the treated larvae could survive. The surviving larvae, with very few exceptions, showed little restriction of movement or other abnormal behaviour. At the moult after the insertion, some died as a result of interference with the moulting process, and some of those successful in moulting developed an out-pouching of the exoskeleton at the point of insertion.

This insertion-type of experiment was repeated with radio-active cobalt wire, with very different results. One hundred per cent mortality of treated larvae resulted in three to five days after treatment. Similar results were obtained with inactive  $\text{Co}^{60}$ , suggesting that the cobalt itself and not the radio-activity was the lethal agent.

The larvae killed by radio-active cobalt insertions were examined, and all parts of the body were highly radio-active, indicating that some of the cobalt had been dissolved and distributed. Silver-plated cobalt pieces were also lethal on insertion, although the time taken for the larvae to succumb was increased up to as long as two weeks.

Cutworm larvae, which are much fleshier than wireworms, were easier to treat by the insertion process. In contrast with the high mortality occurring among wireworm larvae, cutworms survived the insertions of  $\text{Co}^{60}$  wire pieces into the body cavity. A very small percentage of the larvae treated did succumb, however, with symptoms resembling those of the killed wireworms. The fecal matter from these larvae was very radio-active. The remains of these larvae, after removal of the cobalt wire, showed a high radio-active content distributed throughout the body. This was very unlike the condition in surviving larvae, whose fecal matter contained only very small traces of activity and whose remains were only slightly, if at all, radioactive.

Where death occurred after wire insertions it was attributed to puncture of the digestive tract; this allowed the digestive fluids to dissolve the cobalt, which was then distributed throughout the body, causing cobalt poisoning. In the successful insertions the metal apparently did not come into contact with digestive fluids, so that it was not dissolved and the larvae survived. This mechanism would also explain the lethality to wireworms, whose bodies are so small that it is difficult to imagine an insertion not coming in contact with some portion of the digestive tract.

This theory was further substantiated by information obtained during tracing experiments with radio-active cutworm larvae. Cannibalism took place in one of the observation cages. There was no doubt that the cannibalistic cutworm had the active cobalt in contact with digestive fluids. The larva showed a high concentration of activity distributed throughout the body. The fecal matter was highly radio-active. To check on whether a larva with cobalt in the digestive tract could survive, cannibalism was induced in the laboratory and then the surviving larvae were reared normally. Cutworms that devoured their radio-active neighbours died within three days and showed a high radio-active content in all parts of the body.

Once the larvae were tagged externally or internally, depending on the species used, the next problem was detection of the tag. For this purpose a Mains Geiger and Scintillation Probe Monitor was used (Fig. 1). This instrument is a transportable, mains-operated instrument capable of measuring low values of alpha, beta, and gamma radiation with the probe at distances up to 100 feet from the counting rate meter. The probe is an end-on beta-gamma counter tube completely enclosed in brass with the exception of the mica window, which was protected with a wire mesh screen. Five counting ranges, from 200 to 20,000 counts per minute, are available.

The directional properties of this counter were investigated by burying a piece of  $\text{Co}^{60}$  under a certain depth of soil and determining the counting rate at various positions just above the soil surface. The data presented in Table I show that location to within a quarter of an inch (in the horizontal plane) is possible at soil depths up to five inches; at greater depths than this the accuracy begins to fall off.



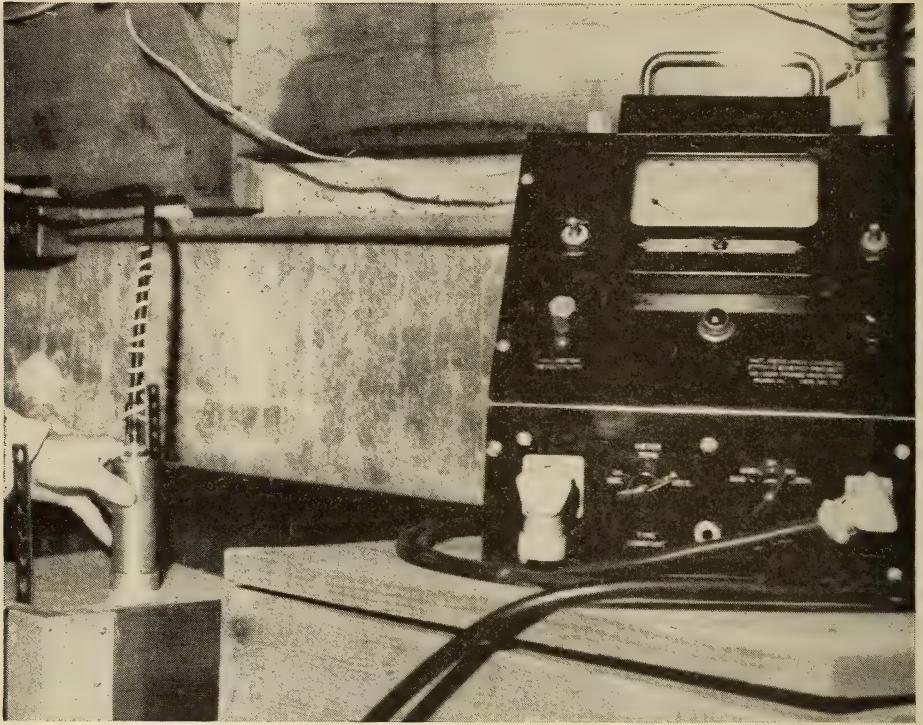


Fig. 1. Counting rate meter and Geiger probe in position to take a reading on the lid of the experimental chamber. This lid has a grid marked on it so that the position of the probe may be determined.

TABLE I  
VARIATION IN COUNTING RATE WITH POSITION OF  
GEIGER PROBE

PROBE POSITION <i>Distance (in inches) horizontally from position of probe when directly over the cobalt piece</i>	COUNTS PER MINUTE	
	<i>Co<sup>60</sup> in fixed position under 2½ in. of soil</i>	<i>Co<sup>60</sup> in fixed position under 5 in. of soil</i>
0	15,250	4,000
¼	15,000	3,900
½	14,500	3,750
¾	13,250	3,600
1	12,250	3,500
2	11,000	3,150
3	6,500	2,700

Before the cobalt pieces could be attached to the larvae, it was necessary to determine the effects of various depths of soil on the counting rate. A plastic cylinder 12 inches high, marked at intervals of one-quarter of an inch, was used for this purpose (Fig. 2). A sleeve made to fit over the counter had just the same diameter as the inside of the cylinder. Two metal rods held by set-screws to a metal lip on the top of the cylinder supported the counter sleeve. By this means the counter could be set at any desired level.

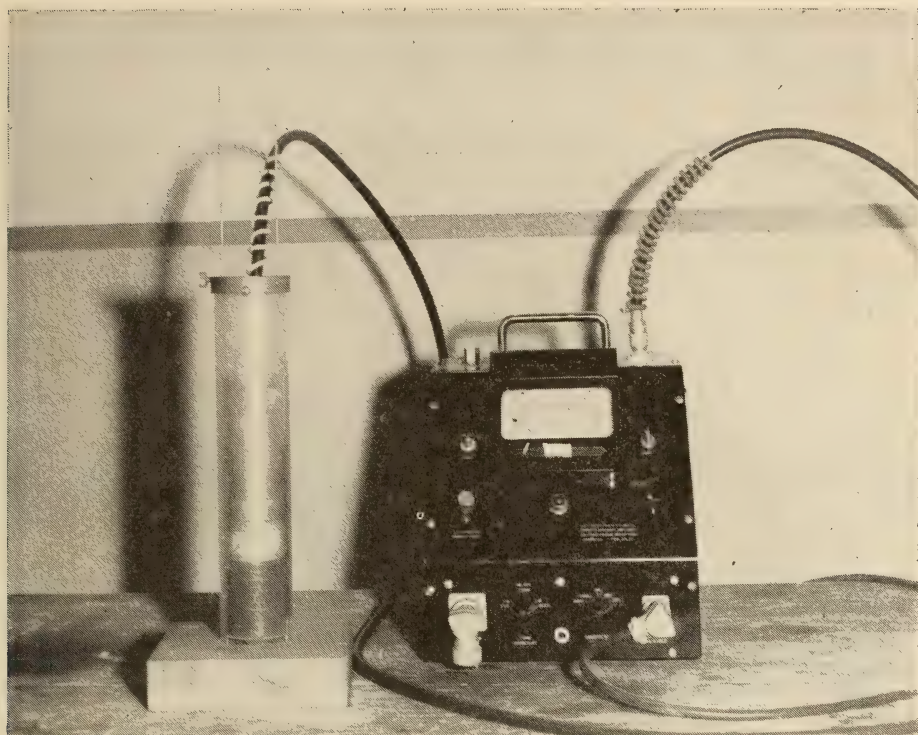


Fig. 2. Calibration apparatus:  $2\frac{1}{2}$  inches of soil covers  $\text{Co}^{60}$  sample at the bottom of the plastic cylinder; attached to the bottom of the probe is a circular disc of the same materials as the lid of the temperature gradient apparatus.

The  $\text{Co}^{60}$  sample was attached to a small plastic card and placed at the bottom of the cylinder. Various depths of soil were introduced and the counter was set at the desired level. Circular discs constructed of materials similar to those used on the lids of the containers were fastened to the end of the counter, to observe their effect on the absorption of the radiations. By this means, the variation in counting rate with soil depth was determined for each piece of cobalt. Unfortunately, although an effort was made to have the cobalt pieces made all of the same radio-active strength, there were considerable variations. A typical result for one such piece of  $\text{Co}^{60}$  wire is plotted in Fig. 3. Since the decay of cobalt<sup>60</sup> takes such a long time, recalibration is not necessary more than once every five or six months.

The effect of soil density on the decrease in counting rate was also investigated. Soils of densities of from 0.23 to 0.43 grams per cubic inch were used, and the results are indicated in Fig. 3. The only effect of a change in moisture content appeared to be from the change in soil density it brought about. The plastic container used in calibration was shown to have no effect on the counting rate.

For soil densities between 0.25 and 0.35 grams per cubic inch, and moisture contents between six and 16 per cent, the counting rates agreed sufficiently for a given soil depth to measure that depth within a quarter of an inch. The Elstow silty clay loam used in all experiments with the larvae was always within the range outlined above, so that depths were determined by means of graphs such as those in Fig. 3.

In detecting a larva tagged with  $\text{Co}^{60}$ , the brass-encased Geiger tube was moved over the lid of the experimental container until the maximum count was recorded on the counting rate



meter. When this was obtained, the larva had been located in the horizontal plane. By recording the value of this count and referring to the graphs drawn up as described above, the depth, or vertical location, of the larva could be determined.

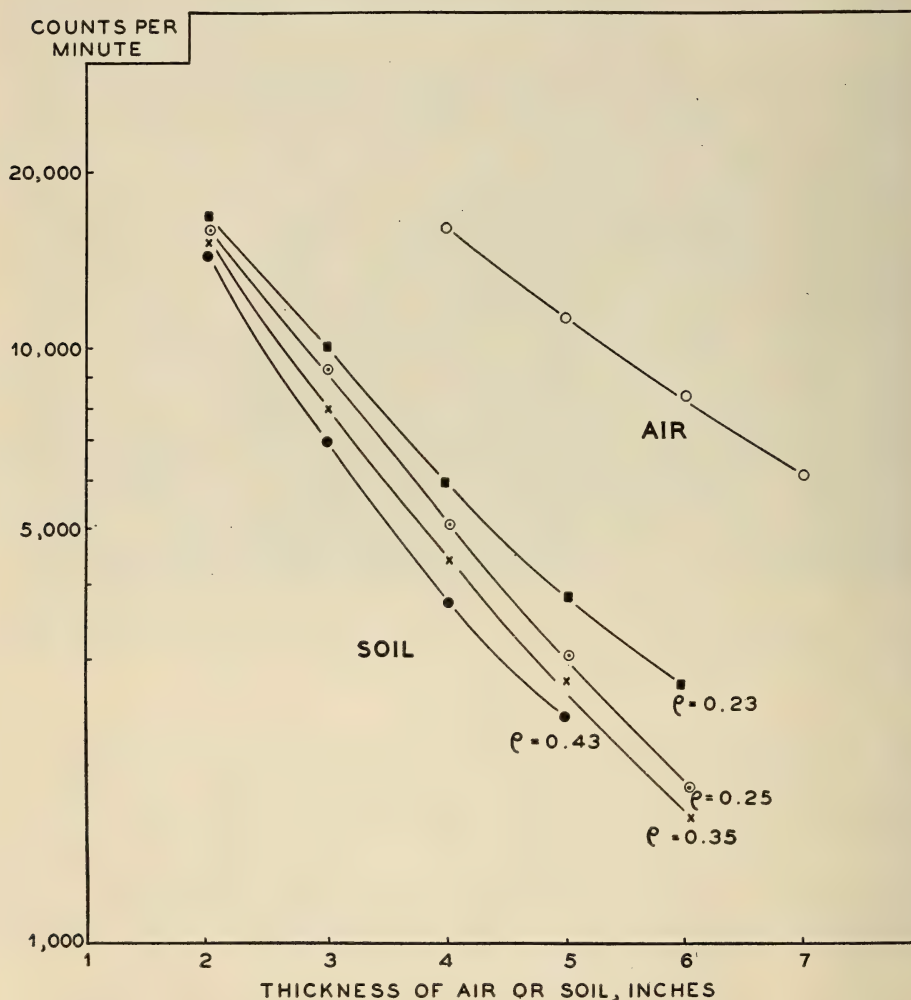


Fig. 3. Curves showing absorption of gamma-rays from  $\text{Co}^{60}$  by various thicknesses of soils of different density as compared with air. The values of  $\rho$  (density) are given in grams per cubic inch.

A check on the accuracy of location was obtained by employing the method of Thorpe *et al.* (1) to follow the movement of an individual larva. A tagged larva was confined between glass plates separated by just enough moist sand to enable it to crawl. The plates were then buried four inches in the soil, and the position of the larva was determined every five or ten minutes by Geiger counter readings. The plot obtained from these radio-active locations was compared with the actual path traced by the wireworm in the sand between the glass plates. The correlation was found to be very good.

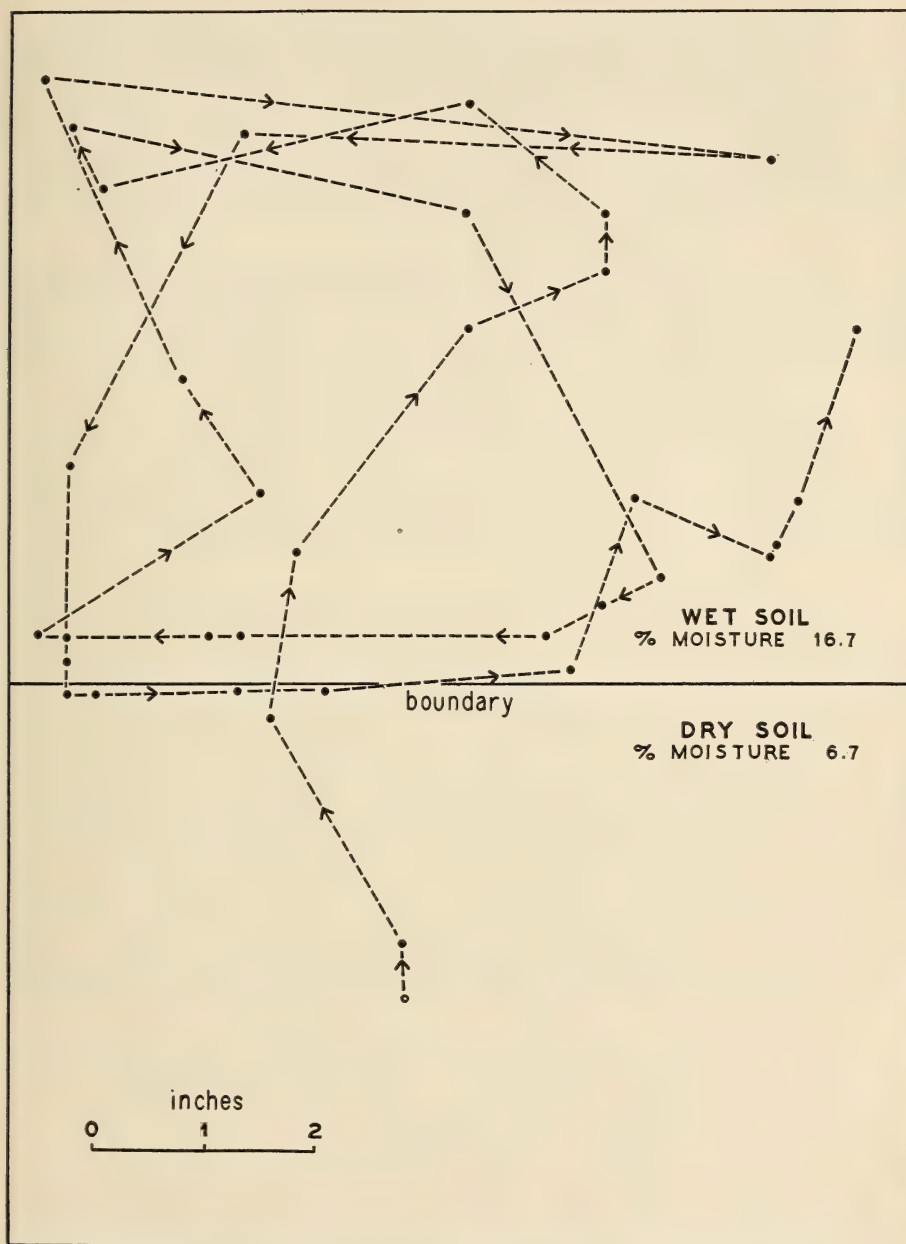


Fig. 4. Movement at a larva of *Ctenicera aeripennis destructor* (Brown) in relation to a soil moisture boundary: diagram of movement in the horizontal plane. The circles represent the positions of the larva at consecutive readings, and the arrows indicate the direction of movement.



## EXPERIMENTS WITH WIREWORMS

A description of some of the studies carried out with the tagged insect larvae will illustrate the use of the method and the type of information that may be obtained. To study some effects of temperature on wireworms, a temperature gradient apparatus was constructed; this consisted of a wooden box separated from a galvanized iron container 74 in. x 12 in. x 8 in. by three inches of rock wool insulation. At both ends of the metal container, there were 12-inch compartments which served as temperature baths; one was maintained at 32°F., the other at 120°F. The wooden lid had a grid in order that the position of the Geiger probe could be determined. Temperature and moisture conditions were recorded by fiberglas soil moisture units\* placed in the soil at intervals along the container.

The paths of larvae placed in the hotter regions of the box were determined. A larva was located by the detection technique described, and continuous readings of position were taken until the larva remained in the same position for several consecutive readings. The larva was allowed to remain in the soil for several hours after the last consecutive reading to see whether it would change its position. A few observations were also made on larvae placed in the box at temperatures below 55°F. The data obtained indicate that larvae of *C. aeripennis destructor* dislike temperatures above 90°F. and show a rapid rate of movement at these temperatures. In the only two cases in which the larvae failed to move from temperatures over 90°, they were dead when removed. In the 80° to 90° region, movement slowed down, and apparently the conditions were more tolerable. However, the preferendum appears to be somewhere in the range of 72° to 76°F. Larvae placed in the region below 55°F. generally remained there although two exceptions were observed.

Some observations on the moisture preferences of wireworms were made. Larvae were observed in choice chambers where they were offered alternative soil moisture conditions, namely, moisture contents of six to eight per cent and of 12 to 18 per cent in the various experiments. A typical result is shown in Fig. 4. Here the larva was placed in the dry side, but, on reaching the wet side, entered, and did not leave it. Although depth of location is not indicated in the diagram, it is interesting to note that on reaching the moisture interface the larva moved down to the bottom of the container and up again, before crawling along the boundary and eventually returning to the wet region. Apparently the drier soil repels the larvae, for in several observations the larvae did not leave the wet region whether they had been placed there originally or had moved there after being placed in the dry side. Once or twice a larva just penetrated the drier region but returned immediately. However, if a potato piece was placed in the dry soil region about four inches from the boundary, the larva sometimes left the wet region. The results, in general, agree with the information obtained by Lees (2) for *Agriotes* sp. using the glass plate apparatus. Here, however, the observations have the advantage that they are three-dimensional in character and the vertical movements can also be studied.

Several paths of wireworm larvae seeking food were obtained. Potato pieces, which are readily attacked by wireworms, were used to see whether the finding of food is a matter of random searching or a directional response to a stimulus. Both the rates and routes of travel for different larvae under approximately the same conditions vary immensely. The larvae were placed about 15 inches from the potato pieces. One larva required only 12 hours to reach the potato piece; others as much as three days; still others did not locate the potato piece.

During these investigations, some observations on the rate of movement of the larvae through soil were made. One larva moved at the rate of six inches in ten minutes in one of the moisture choice chambers. Other larvae moved as much as ten or 12 feet in several hours. Previously, no direct method of measuring the rate of movement of the larvae under normal circumstances was available.

\*Manufactured by Berkeley Scientific Company, Richmond, California.

## EXPERIMENTS WITH CUTWORMS

Radio-active cutworms were used in an effort to determine the fate of larvae placed in open-top experimental cages one twenty-thousandth of an acre in area. These cages were circular galvanized iron bands about 20 inches in diameter pushed into the soil sufficiently far that it was assumed larvae would not or could not escape by crawling over or under the bands. Regardless of the study (behaviour, bait, or dust treatments), fewer larvae could be recovered within one or more days than were put into the cage. Through the use of radio-active cutworms in greenhouse and outdoor experiments it was established that cannibalism, rapid decay after death, and the ability to escape from these cages all helped to account for the loss of specimens.

Studies initiated on the diurnal and nocturnal movements of red-backed cutworm larvae indicated that valuable information on underground habits of the larvae could be obtained by this method. Before observations were completed, these had to be discontinued because of mortality among the larvae, possibly caused by disease.

## SUMMARY

Three species of soil-inhabiting insects were tagged with radiocobalt to study their underground movements, the method of tagging depending on the species. The position of tagged soil insects may be located, at depths up to five inches, to within a quarter of an inch in both vertical and horizontal planes.

Some observations on the response of the prairie grain wireworm, *Ctenicera aeripennis destructor* (Brown), to moisture, food, and temperature were made and information on the rate of movement has been obtained. Radio-active larvae of the red-backed cutworm, *Euxoa ochrogaster* (Guen.), were used to determine the fate and underground activity of larvae placed in open-top cages utilized for chemical control studies and observations on habits of the larvae.

This method permits observations, heretofore impossible, on the behaviour of soil-inhabiting insects in their normal habitat. It is hoped that this brief outline of the work done to date will give some idea of the possible usefulness of the method.

## REFERENCES

1. THORPE, D. W., A. C. CROMBIE, R. HILL, and J. H. DARRAH, 1947. The behaviour of wireworms in response to chemical stimulation. J. Expt. Biol. 23: 234-266.
2. LEES, A. D. 1943. On the behaviour of wireworms of the genus *Agriotes* Esch. (Coleoptera, Elateridae). II. Reactions to moisture. J. Expt. Biol. 20: 54-60.

## DISCUSSION

- A. S. WEST: Has any consideration been given to using an isotopic solution and injecting a larva?
- R. A. FULLER: Our objection to doing this is the difficulty in getting an isotope that they won't excrete. If they excrete the material we will have radiations coming from it. That is also one of the reasons why the feeding of isotopic solutions to larvae is not promising.
- F. O. MORRISON: Another radioactive technique: a Dr. LaLonde working on human histology is working with radioactivity at McGill and has developed a technique, a sort of radio-autograph business. He paints a sensitized film right on to the slide of human tissue. Using normal emulsions he can get down to a resolution of 2-3 microns; i.e. he can practically tell what cell the radioactivity is in.



MECHANIZATION OF ORCHARD SPRAYING IN  
BRITISH COLUMBIA<sup>1</sup>J. MARSHALL<sup>2</sup>*Dominion Entomological Laboratory, Summerland, B.C.*

The hope that hand-spraying might soon be eliminated from British Columbia orchards arose in 1945, when it became evident that exceedingly heavy spray coverage was no longer necessary for control of the codling moth, *Carpocapsa pomonella* (L.). At relatively low concentration DDT had proved outstandingly effective in combating that most troublesome pest of the semi-arid fruit-growing valleys. The introduction to a recently published article (1) traced the development of automatic concentrate spraying from the time it was merely an idea until its commercial adoption. The present account, which takes into consideration progress in orchard spraying practice during 1950, concludes with a brief discussion of ways in which the new spraying procedure may possibly be improved.

The fruit growers of British Columbia, operating some 40,000 acres of orchard land, have quickly adopted the concentrate orchard sprayer. In 1948 about five per cent of the tree-fruit acreage was sprayed by these machines. A year later there was an increase to 20 per cent, and by the end of the 1950 season approximately 75 per cent of the spraying had been done by concentrate applicators. Within another year few conventional gun-type machines will be left in operation, except perhaps for blossom thinning.

Control of all the major orchard pests listed herewith has been satisfactorily accomplished by properly designed and properly operated concentrate sprayers: codling moth, *Carpocapsa pomonella* (L.); tarnished plant bug, *Lygus oblineatus* (Say); black cherry aphid, *Myzus cerasi* (F.); woolly apple aphid, *Eriosoma lanigerum* (Hausm.); green apple aphid, *Aphis pomi* DeG.; mealy plum aphid, *Hyalopterus arundinis* (F.); pear psylla, *Psylla pyricola* Foerst.; San Jose scale, *Aspidiotus perniciosus* Comst.; peach twig borer, *Anarsia lineatella* Zell.; European red mite, *Metatetranychus ulmi* (Koch); Pacific mite, *Tetranychus pacificus* McG.; two-spotted spider mite, *Tetranychus bimaculatus* Harvey; and Willamette mite, *Tetranychus flavus* Ewing. According to E. C. Hunt, District Horticulturist, Nelson, B.C., over a two-year period apple scab control by concentrate sprayer has been comparable to that obtained by growers with conventional equipment. With few exceptions, growers' experiences in areas of scab incidence have confirmed his conclusions.

An interesting but not surprising result in scab control has been that lime-sulphur applied as a foliage spray at ten per cent to 25 per cent concentration by the new sprayers has caused less injury than when applied at two per cent by hand gun. Apart from the acute type of injury that it may cause in hot weather, lime-sulphur is most likely to be phytotoxic when spray droplets dry slowly under conditions of high humidity; concentration of the spray solution seems to be relatively unimportant within the limits mentioned. The fine droplets deposited by a concentrate sprayer do little more than slightly moisten the foliage; hence they dry more rapidly than the much larger ones resulting from hand application. It seems probable, therefore, that concentrate sprayers will help measurably to lessen foliage and fruit injury from lime-sulphur. For growers who operate in areas troubled by apple scab this would be a welcome result because lime-sulphur combines high fungicidal effectiveness with low cost.

During 1949 and 1950 experiments carried out by provincial and federal agencies and by growers have given some evidence that the hydraulic type of concentrate sprayer may be suitable for applying chemical thinning agents. Best results appear to have been obtained

<sup>1</sup>Contribution No. 2753, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada. Presented as an invitation paper at the 81st Annual Meeting of the Entomological Society of Ontario. November 3, 1950.

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with formulations that differed in kind as well as in concentration and in quantity from those applied by hand gun. The practice of chemical thinning is yearly becoming more common in British Columbia, and, in this spraying operation too, a substantial reduction in labour overhead would help to lower the cost of apple production.

The new organic insecticides and acaricides have led to the development of the concentrate sprayer, and these compounds, together with the new machines, have reduced the cost of pest control in British Columbia orchards by over 50 per cent. In 1944, prior to the general use of DDT, most growers applied by hand gun a dormant spray and six summer sprays; now most of them apply by automatic concentrate sprayer a dormant spray and three summer sprays.

Compared with hand application, automatic application saves about 75 per cent of labour cost, about 50 per cent of dormant spray materials, and about 20 per cent of summer spray materials. On the basis of one dormant application and three foliage applications, savings average approximately \$9 per acre on materials and \$16 on labour. Apart from that, a concentrate applicator costing about \$2,000 is capable of spraying 60 to 80 acres if operated ten hours per day. A conventional gun-type machine costing about \$1,500 takes care of 20 to 30 acres. There is, therefore, a saving in capital investment of about \$40 per acre. Finally, the concentrate sprayer has brought automatic spraying to large and small operators alike, regardless of the size of their tractors or the topography of their orchards. That means emancipation from one of the most unpleasant and most heartily disliked jobs in agriculture. For the majority of British Columbia growers spraying is no longer a matter of wet feet, smarting eyes, wry neck, and great resignation. It is an easy job at which, if necessary, the protection of a respirator may be maintained in relative comfort.

Reflecting the new method of orchard spraying, a significant change is being made in the official spray chart for tree fruits. The type of spray formulation in use for nearly half a century is no longer adequate and must be supplemented by another applicable to concentrate spraying. Pounds, pints, and gallons per 100 gallons of spray mixture are about to be superseded by pounds, pints, and gallons per acre.

The principles of concentrate spraying are now fairly well established in British Columbia. An application of 75 to 100 imperial gallons per acre is recommended for mature trees. Approximately 30 minutes is required to treat an acre, with a pump output of 2.5 to 3.3 gallons per minute. In spraying mature trees in rows 30 to 35 feet apart a tractor speed of one mile per hour is necessary; if the trees are 25 feet apart, 1.5 miles per hour; and if 15 to 20 feet apart, two miles per hour. Tree spacing within rows has no bearing on rate of travel.

Not all types of machines available in 1950 for applying concentrate sprays proved capable of doing good work. With equipment so recently developed that is to be expected. In the urge to take advantage of active demand there was a tendency to market untried sprayers. The best of the concentrate applicators, however, are built for continuous operation and they apply toxicants with the necessary uniformity. In inferior equipment, the most serious short coming has generally been its failure to provide sufficient spray coverage in the tree tops. A good machine operating among dormant trees 20 feet high should apply about 80 per cent as much spray material to the topmost branches as to the lower ones. Among well-pruned trees in full foliage it should apply at least 40 per cent as much. These values, somewhat lower than are ordinarily obtained from conventional hand spraying, are more than balanced by the high depositing efficiency of the concentrate sprayer. Even in midsummer, tree-top deposits should be considerably greater than from hand spraying with the same dosage of toxicant per acre. In that connection here is a point that merits careful examination. Despite higher deposits, concentrate spraying has not provided better pest control than careful hand spraying. Presumably the physical condition of the concentrate deposit is inferior. If that is so, it may be possible to improve the efficiency of the concentrate applicator by attention to the liquid spray formulation.



Further investigations on concentrate sprayers and spray formulations can be profitably directed along several lines. The Fruit Insects Laboratory at Summerland is continuing such work as a major project, the scope of which is indicated below:—

1. Nozzles: Comparison of fan, cyclone hollow cone, impinging jet, and venturi types. Elimination of faulty application caused by nozzle abrasion. (This has been one of the chief problems in the operation of hydraulic concentrate sprayers, but an investigation that is on the point of completion at Summerland appears to have solved it.)

2. Airstream: Comparison of air velocities between 50 and 150 miles per hour as to effects on drop size, foliage penetration, and spray deposition. Effect of air volume on the same spray-fog characteristics.

3. Toxicant formulations: Examination of the viscosity and the surface tension of liquids in relation to drop-size of spray fog, impingement of droplets, type of spray deposit, mass of spray deposit, and evaporation of spray-fog between emission and deposition.

4. Liquid pressure: Effect of variation of spray liquid pressure on drop size and on spray coverage.

5. Angle of Airstream: Examination of importance of angle of airstream to the horizontal at point of emission, i.e., comparison of arc-of-circle air vent and "fishtail" type.

There is little question that further improvement will shortly be made in concentrate applicator design, in toxicants, and in toxicant formulations. Regardless of that, however, there seems no doubt that the conventional stationary or portable power sprayer is already a reminder of the past. In British Columbia the automatic concentrate sprayer and synthetic organic pesticides have wrought one of the most notable and certainly one of the most welcome changes in production methods since the founding of the tree-fruits industry.

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#### DISCUSSION

J. A. HALL: We obtained one of the 1949 British Columbia concentrate sprayers and used it last year, and compared it with conventional machines of the power take-off type and the Speed Sprayer. Our results, particularly in scab control, have compared very favourably with the conventional machines, and with much less labour—one man operating the feed whereas with most machines it takes more than one man. With some insects, the codling moth, for instance, the results varied with the type of tree. Where the trees were smaller and somewhat more open, the results with the concentrate applications have been as good as, and sometimes a little better than with the conventional sprayers. Where the trees were high and a little denser we have obtained better control with the conventional machine. The differences have not been too marked, however, and possibly we can overcome some of them by pruning and by changes in certain other orchard practices.

The growers in our section have been watching the sprayer closely. At first some of them were very sceptical. This year, however, growers came in from other counties for the sole purpose of finding out what concentrate sprayers were accomplishing. In late August some orchardists from Oxford County visited, and they were all very favourably impressed with the condition of the foliage and the lack of scab, — quite prevalent in some orchards this year.

We had some mechanical difficulty with our model of the sprayer. Its motor was a little too small for the work required of it, necessitating not infrequent repairs. I understand now that the manufacturer is putting a bigger motor on the machine. Another difficulty encountered was the inability to get adequate coverage if even light winds were blowing. If the wind was over about 5 m.p.h. we couldn't spray at all. Frequently it had to be

done in the early morning or late evening. This year a number of growers whose orchards showed scab, reported that the wind had been so strong that they couldn't get the spray on even with a conventional sprayer. Yet, in spite of this, with the concentrate machine we had no scab.

H. MARTIN: I congratulate Dr. Marshall on his work in B.C. Your work in agricultural engineering is being watched very carefully far beyond B.C. Did I understand quite rightly that the somewhat lower success which has been encountered in the use of the concentrate sprayer against scab was attributed to the actual deposit which is put on by the conventional machine on one hand and the concentrate sprayer on the other hand?

J. MARSHALL: I was speculating, Dr. Martin. It may be that the physical conditions of the particles are not favourable to the full utilization of the fungicidal material. Analyses have shown that in normal spraying the concentrate sprayer is at least twice as efficient in most cases as the ordinary sprayer. I think that a study of the physical characteristics of the deposits resulting from concentrate application would be valuable.

W. A. ROSS: Is the spraying done to-day by an operator who has had experience with concentrate sprayers?

J. MARSHALL: Last year it wasn't. If trees are not pruned you might as well forget concentrate sprayers. That is one reason why the horticulturists have hailed the machine with great glee. One m.p.h. is the speed for most orchards. Lime-sulphur is still our best scab control. We can't use Bordeaux because our fruit russets very quickly. In our country the lime-sulphur causes such a loss from chronic injury that the horticulturists are substituting ferbam and wettable sulphurs. The concentrate sprayer in one man's orchard caused no injury.



## HEALTH ASPECTS OF THE NEW ORGANIC INSECTICIDES<sup>1</sup>

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It was a very great pleasure indeed to accept your kind invitation to join in the interesting and important programme of the Society. The preceding discussion deeply impresses one with the ramifications of the insecticide problem. I am sorry it cannot yet be reported that man is developing resistance to the compounds mentioned. Today, the world of pests has become a matter of universal concern for it is now recognized that freedom from want and maximum well-being of nations depend upon the food-producing capacity of farm and orchard, — upon our ability to grow to maximum yield — to store and distribute with minimum waste. The nutritional standard of man in the post-war world is heavily dependent upon modern pest control. Over vast areas of the earth, man's capacity to produce food is seriously curtailed by the ravages of malaria and other pest-borne disease. It is critically important to all peoples that fullest advantage of scientific invention be marshalled to make possible effective control of insect pests. In this effort Canadian health officials are prepared to take their part.

Among the general public today there is great interest in the new economic poisons which have contributed so much to field and orchard husbandry—to comfort and sanitation in the home. There is also evidence of widespread public concern as to the danger of handling the compounds and ingesting the residues which may accompany food products to market. Much of this concern is unfounded and, as with the fatalities which improper use of certain new insecticides has caused, results from unfamiliarity with the good and bad that frequently accompanies rapid technical change. I am sure that the Canadian Public will be encouraged

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by the time which your Programme Committee has found it possible to give to the health problems of your special field. It is welcome evidence that we may soon find the health aspects equally considered with the entomological effectiveness of the candidate pesticides of the future.

### THE NEW ORGANIC INSECTICIDES

The new group of organic compounds commenced with DDT, a chlorinated hydrocarbon. This exceptional insecticide was followed by numerous other synthetics of related structures which have now been established as agents of importance in economic entomology. Following the war allied technical intelligence representatives discovered in Germany the existence of another group of powerful insecticides — the organic phosphates. The development of chlorinated hydrocarbon and organic phosphate analogs has been joined by the discovery of insecticidal properties for other chemical groups such as the organic sulphur compounds.

A multitude of chemical entities have appeared on the market possessing fungicidal power. Time would not permit a detailed listing of the rodenticides, ovicides, vehicles, synergists and soil fumigants which have been brought to bear on our problems of pest control in the last few years.

The tolerance hearings held at the U.S. Department of Agriculture in Washington this past spring clearly demonstrated that a vast new array of pesticidal chemicals will shortly come forth as candidates for field trial and open market sale. To assess all these compounds for human hazard is a scientific and medical task of first magnitude.

### MAMMALIAN TOXICITY OF THE NEW ORGANIC INSECTICIDE

The introduction of the organic synthetics and improved spraying techniques has enormously increased the potential toxicity of insecticidal covers, but at the same time the danger to operational personnel has also been greatly magnified owing to the employment of certain chemical groupings against which the mammalian forms have but limited detoxifying defence. Prior to the last war the compounds employed in eradicating disease-bearing insects presented little threat to the health of sanitation personnel and with the exception of remote accident possibilities no hazard to the local community was involved. Prewar agricultural practice mainly featured stomach poisons — inorganic chemicals of low human toxicity — and low hazard to the health of farmer and horticulturist was implied, except in the case of the notorious contact poison nicotine which was in limited use by comparison with present day production of the new organics. To summarize, the greater health problem of the current insecticides is due to structural innovations involving (1) higher vapour pressures than older compounds, making for volatility; (2) presence of lipoid solubilizing groups which permit storage in body fat and enhance skin penetrability; (3) unique structural characteristics toxic to enzyme systems and other vital processes. Advanced spray machinery design and application techniques combine with the current trend toward "knock-out" covers of high concentration to create a generally higher level of exposure for operational personnel.

The characteristics of an insecticide and the methods of application constitute only the exposure. To evaluate the mammalian toxicity it is necessary to consider the possible routes of entry to the body—oral, dermal and respiratory. In addition, it is to be kept in mind that while insects are attacked with concentrations adequate to produce acute systemic poisoning, the effect on the exposed mammal may be spread over an extended period of time and result in chronic poisoning which generally produces a different pathology. In the case of humans, the skin introduces the additional possibility of contact dermatitis.

Lehman (1948) published the first appraisal of the mammalian toxicity of the new organic insecticides. This review showed that the chlorinated hydrocarbons and the organic phosphates were the two major groups possessing potentially serious consequences for human



overexposure. The literature records fatalities due to other compounds, notably the dinitrophenols. However, in North America the bulk of the organic tonnages consumed during the past few years has been chlorinated hydrocarbons and phosphates.

Early in its North American history DDT attracted the attention of industrial hygienists and came under suspicion of possessing human toxicity owing to its close chemical relationship to the simple chlorinated hydrocarbons such as carbon tetrachloride and trichlorethylene which many years ago were incriminated as dangerous substances. An additional grouping in DDT — the benzene ring — also suggested that the compound might prove troublesome, for toxicology provides numerous examples where this structural fragment has been associated with affections of the blood and blood-forming organs. Studies on DDT conducted during the war, notably by Lillie and Smith (1944) and Neal and co-workers (1944), (1946) indicated that typical chlorinated hydrocarbon liver damage occurred with chronic exposure. Evidence on human toxicity of DDT began to appear in the medical literature shortly after the war. Wright, Doan and Haynie (1946) reported on agranulocytosis occurring after exposure to DDT pyrethrum aerosol bomb. Leider (1947), Niedelman (1946) and others describe contact dermatitis due to DDT. Various clinical records of human poisoning catalogue symptoms such as nervous tension, involuntary muscular tremors, convulsions, respiratory failure and, in gross exposures, death.

Recently metabolic studies by Telford and Guthrie (1945) and Woodward, Ofner and Montgomery (1945) have indicated that DDT and its analogs may be stored in considerable quantities in animal fat and be excreted in the milk. Further work on storage by Laug and co-workers (1950a) with rats fed DDT-containing diets for 4 to 6 months, indicated that the substance is stored at a level which is 6 to 28 times the dietary intake. In these experiments females stored larger quantities than males. These same animals showed evidence of liver injury characteristic for chlorinated hydrocarbons when diets contained as little as 5 p.p.m. Additional work by Laug and co-workers (1950 b) has shown that in 35 biopsy specimens of human fat, DDT concentration ranged from 0 to 34 p.p.m. and averaged 5.1. In view of these findings and other survey data which indicated clearly that DDT was passed into milk, the employment of the compound in dairy barns has been restricted. Lehman (1950) suggests that the potential hazard of DDT has been underestimated.

Recent laboratory findings on the DDT successors such as Chlordane, Toxaphene, and Methoxychlor indicate that these compounds also possess typical chlorinated hydrocarbon toxicity. Lehman (1950) has revised upward the toxicity rating on Chlordane on the basis of long term feeding studies. It is estimated that this compound is at least four times as toxic as DDT and the opinion is expressed that Chlordane has no place in the food industry where even the remotest opportunity for contamination exists. Chronic feeding experiments also reported by Lehman showed that after 45 weeks of feeding, gross symptoms of poisoning in rats appear at the 75 p.p.m. level in the diet, whereas Toxaphene does not produce symptoms of poisoning at levels of 400 p.p.m. in the diet, before 26 weeks. Recent work by Kunze and co-workers (1950) indicates that Methoxychlor is the least toxic of the chlorinated compounds in current use. Even on diets of 500 p.p.m. storage of as little as 30 p.p.m. was found in the fat of rats, with elimination complete in four weeks after establishment on a cleared diet. This evidence suggests that Methoxychlor can be used safely for direct spraying of livestock. Considerable interest is now being expressed in the new chlorinated hydrocarbon insecticide Aldrin. Unfortunately, this synthetic, like many others, reached open market status before a well-drawn picture of its toxicity could be developed on laboratory animals. Lehman (1950) reports that the compound presents the rare property of being more toxic by skin absorption than by oral ingestion and mentions an approximate ratio of 10:1. An additional disadvantage claimed is the lack of any skin irritation in low concentrations, so that no warning of skin contact is provided. Notwithstanding, Princi (1950) observed no Aldrin poisoning among handlers in primary production. The MLD/50 has been established by Lehman (1950) at 50 mgs. per kg. in rats and this figure has been roughly confirmed by

the findings of other investigators. During the 1949 season, Chlordane was employed for grasshopper control in the Canadian West and during the 1950 season Aldrin was introduced as a more economical substitute. Health records are now being studied to determine whether any ill effects attended the use of these compounds in the field.

The laboratory investigations on the chlorinated hydrocarbons have mainly featured acute and chronic feeding experiments with some work on dermal applications. Differences in toxicity by the dermal and oral routes which have been uncovered in the case of certain compounds, make it probable that toxicity by the respiratory route may differ significantly. For realistic laboratory appraisal of insecticides it is becoming increasingly apparent that inhalation experiments must form an intrinsic part of the testing schedule for any compound. Oral experiments permit assessment of the hazard to human health due to the intake of insecticides residual on food products, but do not yield definite information of value in assessing the hazard to which the industrial worker, farmer and horticulturist may be exposed in the course of handling these synthetic chemicals. To date, the prospect for predicting toxicity from chemical structure has been disappointing.

### ORGANIC PHOSPHATES

The second group of toxic insecticides — the organic phosphates — presents a more clear-cut toxicology but considerably greater hazard. Represented in current North American practice by three compounds HETP, TEPP, and Parathion, this group of new synthetics acts specifically against the esterases of insect and mammal. DuBois and Manguin (1947) found that hexaethyl tetraphosphate inhibited cholinesterase of *P. americana*. Working with the same insect Chadwick and Hill (1947) confirmed these findings on cholinesterase of nerve cord. Koppanyi and co-workers (1947) found similar cholinesterase suppression with various mammalian tissues. Lehman (1950) reports MLD/50 (acute-oral-rats) between 5 and 30 mgms/Kg. for the phosphates and a similar range for dermal toxicity (rabbits). Chronic feeding experiments with rats showed no symptoms of parathion poisoning below 25 p.p.m. in the diet at the 52nd week. Adequate investigation of inhalation toxicity has not been reported to date. Pending further research the full toxicological picture cannot be delineated but all evidence points to the organic phosphates as rapid-acting poisons possessing strong parasympathomimetic activity by oral, dermal, or respiratory routes of entry to the body.

The laboratory findings on organic phosphate toxicity were confirmed early in the 1949 crop season when three deaths and one near fatality occurred in the formulation and packaging of parathion. Subsequently three field deaths in the United States were reported. Analysis of United States experience during the past summer is not yet available but Canada recorded one parathion death and two clinical cases due to thinning of peaches the second day after spraying. Numerous diagnosed cases occurred in the Okanagan Valley, though no fatalities were recorded due unquestionably to alert clinical care. An additional case involved a woman who became poisoned from washing parathion-contaminated clothing. The non-fatal case histories cover exposures which have been severe enough to produce subjective symptoms that directed the patients to medical attention. Clear-cut diagnosis was possible and appropriate treatment with atropine was undertaken. The more serious problems are the cases where lower exposures over an extended period of time deplete the body cholinesterase without distinct warning, at a slow but steady rate, faster than regeneration of this fundamental enzyme can be accomplished. Nausea, vomiting, headache and other such signs tend to be associated with a wide variety of minor ailments as well as with systemic reaction to absorbed parathion and other toxic materials. As a result, medical attention may not be sought quickly enough to neutralize the action of the poisons. Additionally the non-specific symptomatology of early poisoning by both the chlorinated hydrocarbons and the organic phosphates presents difficulty to clinicians when patients do not disclose the chemical exposure in their occupational history.

Analysis of insecticide poisoning during the past two years has revealed that cases fall into two categories. (1) Hypersensitivity which occurs in rare instances and causes acute contact dermatitis or systemic poisoning. These cases cannot be anticipated at present stage of knowledge. (2) Gross exposures and repeated mild exposures leading to systemic poisoning or contact dermatitis. These cases are preventable if the following rationale is observed: (1) proper protective measures to reduce exposure, (2) medical attention when mild illness of any kind occurs, (3) those exposed to insecticides should not fail to advise physicians as to the nature of the chemicals handled.

### EXPOSURE AND CONTROL MEASURES

The organic insecticides, in the course of a few short years, have come to present a challenging new problem to those charged with introducing the new compounds and caring for the health and safety of the public. In the Department of National Health and Welfare it is felt that this is primarily a task for industrial hygiene, which has developed over the years specialized medical and environmental techniques capable of permitting safe manipulation of the multitude of poisonous materials which have preceded the organic insecticides. By co-operative action between agricultural and health agencies at Federal and Provincial level all phases of the problem, from hazard in manufacture to the residue question with marketed produce, can be solved.

First human exposure to an insecticide occurs in manufacturing synthesis. Protection of industrial workers under the type of organized conditions which generally prevail in industry today presents a manageable problem through the employment of such techniques as closed processes, exhaust ventilation, personal respiratory protective devices and cleanliness regimens; these measures being supplemented by routine medical supervision.

Formulation of preparations involves extensive manipulation of concentrated materials. At this stage, as well as in packaging and bottling, rigid precautions are necessary if health of the employee is to be protected. Such work is not generally carried out by the manufacturer but is taken on by smaller concerns which specialize in formulation. Under these circumstances, the health problem looms for it has been found in the case of other industrial hazards that the smaller the organization, the more difficult becomes the problem of proper health control owing to the capital outlay necessary for ventilation and dust collection equipment, as well as the operating expenses of providing close medical supervision of exposed employees.

The application of the new insecticides by the individual farmer and horticulturist constitutes the major health problem in unrestricted use of these important economic aids. The size of the operation is at a minimum. There is an unfamiliarity with the handling of dangerous materials. Capital investment is low and financial outlay for health protection must compete with narrowly-budgeted operations expenditures. Currently, commercial distribution facilities for safety equipment are geared to the concentrated industrial market and such equipment is not easily obtainable in rural areas. These factors combine to present a discouraging prospect for the employment of safe practices when highly toxic insecticides are applied. Quite apart from the intrinsic toxicity of the particular insecticide being used, there is a trend toward more hazardous methods of application. Aerosol-type spraying and dusting are increasing and this practice makes for fine particles which remain air-borne longer and penetrate the respiratory tract more deeply. The necessity to work around trees and plants following spraying creates a serious potential exposure to residual insecticide, realized this past summer by the tragedy at Port Burwell. Finally, concentrations of insecticide in spray mixtures and dusts are being increased in some areas to offset immunity which certain common pests have been noted to be developing. The sole circumstance mitigating against hazard is the intermittent character of the field applications, but this affords no protection against the rapid-acting poisons.



Recent study in the field has revealed serious malpractices in insecticide application. On the basis of the findings, the Department of National Health at Ottawa will shortly make available an instructional strip film. Hand mixing of bait and powder for sprayers was frequently noted. Skin absorption and inhalation of vapor become serious matters when protective gloves and respirators or masks are not worn. The precaution of wearing respirators is still resisted, and possibly with some justification, for the discomfort factor is high. Nevertheless, health, under field conditions, cannot be protected by any other means in the presence of toxic vapors. Possibly the most serious condition observed was the practice of wearing unprotected fabric clothing over a period of days, during which extensive accumulation of active material takes place and creates for the whole body a toxic environment which the most vigorous constitution cannot indefinitely resist.

Education at worker level in proper methods of protection is the fundamental requirement for safety. Certain companies have seriously undertaken to instruct customers how to use their products without ill effects. Other companies will, no doubt, adopt this practical approach, for one cannot fail to recognize the intelligent and responsible attitude of the industry as a whole in connection with the health problems presented by the new materials. With few exceptions, the insecticide producers today adopt the point of view that sale of a potentially poisonous compound on the open market carries with it a measure of responsibility for customer safety that goes beyond the mere listing of precautions on labels. Furthermore, it is our experience that the ethical manufacturers now recognize the basic importance of carrying out careful studies of oral, dermal and respiratory toxicology as a normal aspect of new product development. Common sense dictates that new chemicals should be screened for human toxicity before they are placed on the open market. Thereafter, rational educational programmes for customer safety can be based upon scientific knowledge of toxicity, physical properties of the preparation and technique of application. Primary screening of new products and subsequent safety education must become the rationale of marketing.

Among authorities in the field a considerable body of opinion favours the suppression of insecticides toxic to warm-blooded animals beyond certain limits. In other quarters it is considered that compounds dangerous to man should be employed only by licensed pest control operators or by large field operations where organized conditions of work permit the application of industrial hygiene procedures. As regards insecticidal residues on food products, certain specialists consider that application of insecticides should be controlled so as to prevent the use of dangerous materials under such circumstances. All these considerations imply complex controls, restriction and regulation in contra-distinction to the traditional freedom with which agriculture and horticulture have long been pursued.

#### THE GOVERNMENTAL POSITION

At the present time the sale of pest control products in Canada is relatively unrestricted. The Pest Control Products Act, a Federal Statute, requires as a condition of licence that poisonous products be so labelled. In addition such products must be capable of being employed safely with reasonable precautions. To satisfy this requirement, extensive field experience under controlled experimental auspices including medical supervision is obviously necessary in order to assess hazardousness and routine of precautions prior to licensing under the Act.

The health problems associated with organic insecticides have been under continuous study in the Department of National Health for many months past. A close working relationship has been established between the Division of Entomology of the Federal Department of Agriculture and the Industrial Health Division of the Department of National Health and Welfare with a view to ensuring prompt health consideration of promising insecticides. The Industrial Health Division acts in a technical advisory capacity to the Plant Products Division of the Agriculture Department which administers the Pest Control Products Act. In this fashion the administrators of the Act are able to obtain an estimate of the potential health hazard of

products which may be candidates for licence under the Act. The Food and Drug Division joins in the work when occasion arises to consider materials likely to be employed in food and drug situations. Additionally, the Industrial Health Division prepares and distributes evaluations on toxicity of new compounds and cooperates with Provincial Health Departments in their efforts to make possible safe handling of insecticidal aids at factory, farm and orchard level. Whether this approach to the problem will prove adequate in the future will depend largely upon current safety experience, for there is little evidence to point to the forthcoming presentation of ideal materials having high insecticidal potency and negligible toxicity to man.

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## DISCUSSION

- H. A. U. MONRO: What is your opinion of the toxicity of lindane?  
 K. KAY: I purposely didn't present a table showing comparative toxicity of this and other compounds, because we find that there is considerable changing of minds about this. At the moment it is regarded as having the next lowest toxicity to methoxychlor, i.e. with regard to feeding toxicity only. What its toxicity would be from the point of view of dermal poisoning or inhalation, I have no idea.  
 H. A. U. MONRO: Have you any information regarding the question of the absorption of methyl bromide through the skin?  
 K. KAY: I can't recall anything specifically on methyl bromide through the skin. The dermal problem is in a very chaotic condition, due to disagreements about experimenting on dermal poisoning, and as a result it is not a phase of the problem on which it is fair to make any statements. To-day there is a tendency to feel that the respiratory hazard has been overestimated, and that we haven't been paying enough attention to skin absorption. There has been a great deal of emphasis on selecting proper respirators and inducing people to wear them, and perhaps not enough on proper clothing.  
 G. F. MANSON: What is the attitude of your Department toward carrying emergency atropine for field workers using parathion?  
 K. KAY: The Department is against it. It suggests instead that the availability of medical attention should be looked after by the people working with parathion. It feels that atropine is a very dangerous drug, and should not be handed out for use by inexperienced people. We feel that medical service should be made available where parathion is being used.  
 H. A. U. MONRO: One thing we have done is have the men carry some information for the doctor. The average doctor does not know what to do in cases of poisoning by these new insecticides.

- K. KAY: The Department looks very favourably on the current practice of notes to physicians on labels. I will make a note of your suggestion to bring up before my Department.
- W. A. ROSS: Was not the note on parathion poisoning sent to all physicians in Canada?
- K. KAY: I understand it was but do not know for sure.
- J. A. HALL: The doctor on the case at Port Burwell, had no information at all.
- K. KAY: Parathion seems to have been in use for a long time, but its general use in Canada seems to be rather recent, and I think it will take some time before that information is known by the medical profession.
- J. A. HALL: I believe that it has been in medical journals.
- H. A. U. MONRO: I still maintain that the responsibility should be with the people who are working with the poison, because doctors are too busy to know everything about all the new and very deadly poisons.
- K. KAY: Mr. Monro mentions a very important fact, i.e. that there must be a responsibility with the person spraying with the very deadly poisons, or someone responsible in charge when insecticides such as parathion are used. He should direct men to a doctor if occasion arises, and be familiar with any first-aid treatment which may be applied.
- H. A. U. MONRO: Is there an indication of wide variation in susceptibility of individuals to parathion poisoning?
- K. KAY: It is very difficult to classify these, due to the rareness of cases of poisoning. Why the odd person should succumb is a mystery.
- W. A. ROSS: With the large number of people using parathion, there have been very few who have been poisoned by it. I wonder if those of us who are interested in this problem could meet with Dr. Kay this afternoon.
- K. KAY: It would be a pleasure. Dr. Cunningham of the Ontario Division of Industrial Hygiene is also here. Possibly he would meet with us.



## HISTOPHYSIOLOGY AND INSECTICIDE ACTION<sup>1</sup>

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Some entomologists have for some time now thought that our knowledge of insect toxicology could well be advanced by a study of the more histological aspects of insect physiology. The term histophysiology can, it is submitted, reasonably be used to describe this field of study; indeed the word is already in the literature (Wigglesworth, 1947).

The object of this paper is to attempt to review and correlate some of the work in insect histophysiology that has a bearing on the subject of toxicology; firstly, by reviewing some of the tissue changes in insects that have been described as being associated with the administration of toxic materials; and secondly, by discussing some of the recent findings on insect histophysiology that affect our knowledge of insect toxicology.

The study of tissue changes associated with the administration of toxic substances has been regarded by some, and particularly by Richards and Cutkomp (1945), as of very limited value, but it is worth noting that the medical and veterinary scientists seem to find the study of the tissues of poisoned animals of some value; and it seems likely that the study is not as barren of possibility as the critics suggest.

<sup>1</sup>Presented as an invitation paper at the 81st Annual Meeting of the Entomological Society of Ontario, November 1, 1950.



That greater knowledge of the fundamentals of insect histophysiology should throw light on the problems of insect toxicology is becoming more generally appreciated. Indeed it would seem not unlikely that progress in our knowledge of insect toxicology is dependent to a great extent upon the progress in our knowledge of the more fundamental aspects of entomology, particularly of histophysiology; that advances in toxicology will come both from increased knowledge of the insect and from increased knowledge of chemical poisons.

It is generally accepted that there are three routes by which a toxic material may enter an insect: by the alimentary canal (the so-called 'stomach poisons'); by the general and particular body surface (the so-called 'contact insecticides'); and by the spiracles into the respiratory system (presumably, the method of entry of fumigants). The terms 'residual insecticide' and 'systemic insecticide' (Martin, 1949) are of relatively recent introduction to describe materials such as DDT on the one hand and the new organic phosphorus compounds on the other. These terms, it would seem, are arbitrary, but they are useful in practical toxicology. It may be that a changed attitude towards them may become necessary. For example, it is surely not impossible that some of the so-called 'stomach poisons' may enter the insect through the cuticle of the mouthparts, through the cuticle of the foregut, through the peritrophic membrane or through the cuticle of the hindgut. We have no information on these points. It is known, in the few insects that have been studied, that the foregut lining is impermeable to water; that the peritrophic membrane is probably permeable to digestive juices and the products of digestion; and that the hindgut is permeable to water (Wigglesworth, 1947). If a poisonous material is absorbed through any part of the gut or body wall it is of interest to know if those tissues are in any way affected: if, for example, signs can be detected of interference with secretory activity or with the cellular layer. Recently Miss Salkeld, working at the Ontario Agricultural College, has investigated the histological changes in the midgut of the honey bee associated with the administration of three insecticides as 'stomach poisons'. She used DDT (2,2-bis-(p-chlorophenyl)-1,1,1-trichloroethane), parathion (0,0-diethyl o,p-nitrophenyl thiophosphate) and acid lead arsenate in accurately measured doses (Salkeld, 1950, 1951). The great difficulty in this kind of work is the making of legitimate assessments of damage due to the poisons as against normal post-mortem changes. This is rendered the more difficult as we know nothing of the histology of recently dead insects. Salkeld adopted a number of expedients to overcome these difficulties: standardization of all procedures, constant reference to check material, and the use of what may, perhaps, be called physiological time. That is, instead of examining bees killed by all the poisons at the same standard time after administration of the poison, she removed the tissues for examination when the insects had reached a particular condition in their progress towards death. In this way, slow acting insecticides, it was thought, would be given a chance to exert their effects. Salkeld found certain tissue differences which she considered were associated with the administration of the insecticides, and, based on these, she suggested, tentatively, that while arsenic appeared to have a direct action on the cells of the midgut, DDT and parathion probably entered the insect through the cuticle of the foregut; DDT then affecting the gut nerves and causing continuous activity and exhaustion, and parathion causing rapid death without much affecting the midgut.

There is some independent physiological support for these views: Tietz (1924) found that arsenic was one and three-quarters times more soluble in the fluids of the honey-bee ventriculus than in distilled water; DDT and parathion are only slightly soluble in water; and there is evidence that DDT (Bodenstein, 1946) and parathion (Metcalf and March, 1950) are both nerve poisons of some kind. It is likely that an extension of Salkeld's work would yield results of considerable interest. Such work is of a pioneering kind and even negative results have much value.\*

\*After this was written a very interesting recent contribution was noted: "A study of the processes of digestion in certain insects" by Day, M. F. and Powning, R. F. (1949) in Australian J. Sci. Res., Series B, 2: 175. This work included studies of mitoses in midgut cells and a discussion of the 'Histopathology of Insecticides'.

Some similar work has been done with insect nerve tissues (Hartzell). Richards and Cutkomp, however, have expressed some criticisms of the work and it may be that nerve tissue, in particular, is the least satisfactory for histophysiological studies of toxic action, despite its use by Laüger *et al.* (1945).

Yeager *et al.* (1942) have been able to show that the blood of an insect may play some part in its resistance to poisons. They were able to achieve functional blockage of the haemocytes of the cockroach with Chinese ink (carbon particles) and to show that insects whose haemocytes were blocked in this way were less resistant than the checks to sodium arsenite applied in small doses as a contact insecticide.

There is little work relevant to the present paper on either oenocytes or the fat-body. However, Kramer and Wigglesworth (1950) have recently postulated that oenocytes are concerned in the secretion of the cuticular waxes (see below), so that toxicity studies involving observations of oenocytes might well prove fruitful. The fat-body contains a great variety of storage products (Bishop, 1922; Schmieder, 1928 and Wigglesworth, 1942), such as glycogen, fat and protein. Merrill, *et al.* (1946) have found biochemically a marked depletion in total body glycogen and glucose and an increased fat utilization in DDT-poisoned insects. Such changes are not unlikely to affect the fat-body and it is possible that they might be detectable histologically.

Studies of the histophysiology of poisoned insects like those just described advance our knowledge of toxic action by helping towards a fundamental explanation of the action; but there is another great field of insect histophysiology that has recently contributed much to our better understanding of insecticide action; and this is the histophysiology or microscopical functional morphology of the normal insect. Advances that are of considerable interest to toxicologists have been made in our knowledge of the insect cuticle and the insect egg shell.

Early work on the insect cuticle was due to Chatin (1892) and Kuhnelt (1928) among others; but in 1918, Moore and Graham suggested that the insect cuticle probably had a waxy or fatty covering. Recent work on the insect cuticle is due in varying degrees to Ramsey (1935), Pryor (1940), Wigglesworth (1948), Hurst (1948), Dennell (1946), Beament (1945) and Way (1950). Ramsay noticed that droplets of water on the cockroach cuticle became covered with an oily film and he claimed that the oily material was derived from the cuticle. Pryor showed that the cockroach ootheca was formed from protein tanned by certain phenol derivatives. The expression "tanned", apparently taken from the leather industry, is used to describe the introduction into the protein molecule of certain links so that a soft, easily decomposed protein becomes a tough resistant material like cuticle or leather. In leather, Jordan Lloyd (1943) has said "The function of the tanning agent appears to be to displace the cross-links of the natural protein fibre . . . and to replace them with a more stable type of linkage". Since Pryor's paper, much has been written on the subject of tanning in the animal kingdom, for example: Wigglesworth (1948), Picken and Lotmar (1950), Nurse (1950), Blower (1950) and Burton and Stoves (1950).

The least complex account of the insect cuticle is Wigglesworth's description of that of *Rhodnius prolixus*. He considers that the cuticle consists of an endocuticle of soft protein and chitin (a complex polysaccharide), and exocuticle of "tanned" protein and chitin and a thin complex epicuticle consisting of a layer of cuticulin covered by a polyphenol layer, covered by a wax layer, covered by a cement layer. The wax layer waterproofs the insect and its presence is, of course, of considerable interest to toxicologists, for it would seem likely that upon it, to a considerable extent, depends the permeability of the insect to poisonous materials. Indeed, Wigglesworth (1944) has shown that the action of so-called "inert" dusts is due to the scratching of the wax layer and the subsequent consequent desiccation of the insect. Beament (1945) has made an extensive study of cuticular waxes. He has found that the precise type of wax varies with the species of insect. Permeability of the wax layer to water increases suddenly at a particular temperature just below the melting point of the wax. He calls this temperature the "transition point" and postulates that at it the wax layer becomes disorganized. He found, too, that chloroform vapour could cause an increase in perme-

ability of the wax layer—a finding of some interest for those who conduct laboratory tests with insecticides, as it indicates that caution is necessary in viewing results obtained with anaesthetized insects. It is interesting here to note that Page *et al.* (1949) have obtained, by a study of “knock-down” of pyrethrins, a measure of the thickness of the epicuticle which is in close agreement with Beament’s histophysiological determination. Wigglesworth’s (1948) account of the cuticle of *Tenebrio* is in general agreement with his account of the *Rhodnius* cuticle. Dennell (1946) has studied the cuticle of the larva of *Sarcophaga* in which he found that the epicuticle consisted of two layers. Hurst (1948) has written several papers on the cuticle of the larvae of the higher Diptera: he postulates a very complex structure and seems to regard the outermost layer as a lipo-protein mosaic. Apparently, it is thought (*vide* Disc. Faraday Soc. No. 3) that Hurst’s concept of the cuticle is unnecessarily elaborate. However, Thorpe (1948) has taken some ultra-violet photomicrographs of part of the cuticle of the water bug *Aphelocheirus aestivalis* and found that they do not support in detail the views on the epicuticle of either Hurst or Wigglesworth. Recently, Way (1950) has published an extensive account of the cuticle of *Diataraxia oleracea* (Lepidoptera). This cuticle apparently is fundamentally not very different from the *Rhodnius* cuticle but it undoubtedly differs in many details. Way discusses his findings in the light of other work on cuticle. Discussing some of these ideas in association with some of his own experiments, Webb (1950) has recently suggested that it is as important that an insecticide be water soluble as that it be oil soluble; for it must be soluble in the protein as well as in the “fatty” part of the cuticle. Furthermore, he suggests that the action of certain liquids that aid penetration is due to their ability to make the insecticidal material more soluble in water. This is surely the phenomenon of hydro-tropy\*; and it is of interest that Musgrave (1946) suggested it as a possible way in which DDT might be translocated within the insect.

Several investigators have favoured particular parts of the cuticle as the sites of entry of ‘contact’ insecticides. The sense organs (Musgrave, 1946; and Roeder and Weiant, 1946) have been suggested by some and the tarsi by others (Laüger *et al.*, 1944; Burt, 1945; and Hayes and Liu, 1947). There is no histological evidence that the sense organs play any part in insecticide entry. But Hayes and Liu (1947) have indicated some association between tarsal structure and DDT-sensitivity and recently Slifer (1950 b) has shown that the arolium of the grasshopper is, at times, permeable to water soluble dyes: the grasshopper that had just undergone ecdysis had impermeable tarsi but older specimens and those with rubbed tarsi had permeable arolia. Apparently it was Minnich who first showed (1921–1932) that insect tarsal chemo-receptors were effective, for some insects can ‘taste’ with their tarsi, (see also Marshall, 1934), but it was not until the 1940’s that the implications of his findings were realized by entomologists. For here, it seems, is an excellent entry site for contact insecticides.

The spiracles have been a favourite with entomologists as the site of entry of insecticides. It seems, however, that despite recent research (Richards and Korda, 1950) we, as yet, know too little of the cuticular intima of the tracheae to discuss the entry of insecticides by this means, though it was shown many years ago by Moore and Graham (1918) that certain very definite physical properties were required of a liquid in order that it might penetrate the tracheae.

One very fascinating branch of insect histophysiology in which considerable progress has been made is that which deals with the insect egg shell. Until recently, virtually nothing was known of the structure of the insect egg shell. Beament (1946 a & b, 1949 a & b) has, however, recently described the results of several years work on the shell of the egg of *Rhodnius prolixus*; Slifer (1937, 1938, 1949, 1950) has described the structure of the shell of the grasshopper *Melanoplus differentialis*; and Moscona (1950) has described the egg shell of the Phasmid *Bacillus libanicus*.

\*A hydrotropic substance is one capable of causing the greatly increased water-solubility of a substance normally only very sparingly soluble. (See Thorpe, 1947 for an introductory discussion.)



In 1937 Slifer described the outer shell or chorion as "many layered" but she showed only two layers in her diagrams. Beneath the chorion were later secreted two layers of tough material. Subsequently, one of these layers was digested away by the developing embryo before hatching. Later (1938), she described a water-absorbing area of the egg which she termed the 'hydropyle'. If eggs could not absorb water they died. It had been known that the chorion was secreted by the follicular epithelium (Gross, 1903; Musgrave, 1937; and Slifer, 1937). Beament decided it was necessary to limit the term 'chorion' to such layers as were secreted by the follicular epithelium: in *Rhodnius* egg he found seven; in addition, he found that the developing oocyte secretes a waterproofing wax layer onto the inner surface of the chorion. He was able to show that many chemically simple liquids can penetrate the egg shell only through the micropyles, which are, properly, the means of entry for the sperm. The female *Rhodnius* attaches her eggs to the substrate with a cement and this cement frequently occludes the micropyles; furthermore, he found that young females produce more than old females. Here is an excellent explanation of the heterogeneity sometimes found in ovidice tests with the attached type of insect egg (see, for example, Callaway and Musgrave, 1940, on eggs of the bed-bug, a distant relative of *Rhodnius*).

During the fifteen days between laying and hatching the eggs of *Rhodnius* were found to increase in resistance to simple chemical poisons till about the twelfth day, when resistance decreased again. Beament studied the subchorial membranes of the egg and found that several were laid down by the developing embryo and the egg reached maximum resistance. As the time for hatching approached some of the subchorial membranes were dissolved and egg resistance decreased again. Clearly, in ovidice testing the age of the egg is a very important factor; not only this but it is important to know how precisely age should be determined: may the results obtained with an ovidice against eggs 2 days  $\pm$  12 hours old be compared reliably with results obtained with eggs 2 days  $\pm$  24 hours old? It would, presumably, depend upon what changes occurred in the egg shell in the extra hours.

Very recently, and perhaps stimulated by Beament's work, Slifer (1950a) has returned to her study of the insect egg shell and she has made observations of considerable interest to toxicologists. Young eggs of *Melanoplus differentialis* are highly susceptible to poisoning by iodine in potassium iodide but during diapause they are unharmed. During diapause the hydropyle (or water-absorbing area of grasshopper egg shell) is protected by a wax layer. When diapause is over, iodine can again enter the egg and it is susceptible to poisoning. There is a close correlation between the permeability of the hydropyle and the presence of a layer of wax or wax-like material and the susceptibility to iodine in potassium iodide. Obviously, it is of importance to treat insect eggs with ovidices at their most susceptible time.

The egg shell of the Phasmid (Orthoptera) *Bacillus libanicus* has been described by Moscona (1950). The egg is covered by three main envelopes: an exochorion of seven layers, a double-layered endochorion and a vitelline membrane. Two of the layers of the exochorion consist largely of calcium salts. During development of the egg part of the calcium carbonate layer of the exochorion becomes dissolved and lost.

It is noteworthy, too, that Christopher's (1945) description of the *Culex* egg raft indicates yet another type of insect egg shell.

It is surely reasonable to submit that these fundamental findings help to a better understanding of ovidical action.

It is known that some insect eggs absorb water from the leaves on which they rest (See Slifer, 1938, quoting Reaumer, 1740, and Weber, 1931; see also Wigglesworth, 1947), yet little is known of the precise mechanism. It therefore seems not improbable that with the development of systemic insecticides it may be possible to kill insect eggs by means of these insecticides. This is speculation, for much more work is needed. Present indications are that systemic insecticides are nerve poisons and would thus be ineffective against young undifferentiated embryos.

This has been a very brief review of an extensive field of study, but it is hoped that it has helped to generate an appreciation of the great significance of fundamental work on the microscopical aspects of insect physiology, not only to entomologists in general but to toxicologists in particular, and to practical agriculturists and pest control workers.

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## SYMPOSIUM

on

## THE DEVELOPMENT OF RESISTANCE OF INSECTS TO INSECTICIDES

The recent increase in instances of insect resistance to insecticides led the Programme Committee to invite a number of workers to present a symposium on the subject at these meetings. Dr. A. W. A. Brown agreed to serve as the discussion leader. The following presented papers:

A. W. A. BROWN, Department of Zoology, University of Western Ontario.

HUBERT MARTIN, Science Service Laboratory, London.

H. H. SCHWARDT, Department of Entomology, Cornell University.

H. A. U. MONRO, Science Service Laboratory, London.

\*C. R. TWINN, Division of Entomology, Ottawa.

\*L. A. ROADHOUSE, Division of Entomology, Ottawa.

\*C. G. McNAY, Division of Entomology, Ottawa.

D. P. PIELOU, Dominion Parasite Laboratory, Belleville.

F. O. MORRISON, Department of Entomology, Macdonald College.

\*W. E. BLAUVELT, Department of Entomology, Cornell University (read by C. E. PALM).

The contributions of those marked with an asterisk were either of the nature of progress reports or are to be published elsewhere.

A combined list of the references cited is included at the end of the Symposium.

## THE DEVELOPMENT OF RESISTANCE OF INSECTS TO INSECTICIDES

A. W. A. BROWN

*University of Western Ontario*

My part in introducing this discussion will be to outline the history of resistance, in order to provide a background for the advanced knowledge of the chosen speakers to follow. The development of resistance to insecticides by certain species of insects is no new thing; and its history dates back almost to the earliest application of these insecticides, if allowance is made for the inevitable delay in the detection of its existence.

In 1908 it was first established that a resistant strain of the San Jose scale (*Aspidiotus perniciosus*) was present in the Clarkston valley of Washington state, because its average survival rate was 17% to doses of lime-sulphur which left no survivors of the normal strain. A similar race was also detected in southern Illinois. The Clarkston strain showed no progressive increase in resistance during the succeeding 15 years.

Subsequently, resistant strains of three species of coccids developed in the citrus groves of California where hydrogen cyanide was used as a tree fumigant. In 1912, populations of the black scale (*Saissetia oleae*) at Charter Oak were found to show 20% survival to doses which normally left only 1% as survivors. By 1938 this resistant strain was present throughout the entirety of Los Angeles county. In the same year, resistance to HCN appeared in the California red scale (*Aonidiella aurantii*) at both Corona and Orange; by 1946 it was present in the citrus groves of both the coastal belt and the interior of the state. As with the previous species, the resistant strain showed 20% survival to doses which normally left only 1%. Finally in 1925, a HCN-resistant strain of the citricola scale (*Coccus pseudomagnoliarum*) appeared at Riverside and by 1938 was present throughout the range of this species. Its survival rate was 50% to doses which allowed only 10% of the normal strain to survive.

The nature of this resistance was studied in the case of the red scale. From a physiological standpoint, the resistant strain was found to attain the condition of protective stupefaction in a shorter time, and to maintain spiracular closure against the entry of HCN for a longer time, than the normal strain. Upon genetical investigation, the resistance was found to be sex-linked, such that the haploid males resembled their diploid mother in resistance; and to show no dominance, to the extent that the heterozygous females were intermediate in resistance. Successive generations of the resistant strain maintained their resistance even in the absence of HCN, but the resistance of the stock was found to increase upon further exposure to this fumigant.

By 1928 it was definitely established that the strain of codling moth (*Carpocapsa pomonella*) in the Grand Valley of Colorado was resistant to acid lead arsenate. It required 10 to 12 cover-sprays for control where originally 2 had been sufficient in 1900. When compared with a strain from Virginia (a 4-spray region), the Colorado larvae showed themselves to be larger and more resistant to desiccation and starvation; thus they could wander over the sprayed fruit for a longer period and thereby had a greater chance of finding a point of entrance uncovered by the arsenical. Genetically, the factor or factors were neither dominant nor sex-linked; the hybrids were intermediate in resistance, and the reciprocal crosses were identical. It was found in 1928 that the *Carpocapsa* populations in the Yakima valley of Washington were at this intermediate level of resistance. A progressive increase in resistance was noted at Wenatchee, Washington from 1930 to 1932, and by 1943 it was noted that even the Virginia

populations showed twice the resistance that they did in 1918. In 1943, it was reported that larvae of *C. pomonella* infesting walnut orchards in California had developed an increased resistance to basic lead arsenate.

In 1938 a strain of the blue tick (*Boophilus decoloratus*) that was resistant to sodium arsenite was reported from New London, South Africa. The level of resistance was such that cattle dips that had formerly killed all but 1% of the ticks, now left an average of 63% as survivors. By 1945 this resistant strain had spread southwards throughout Cape Province and northwards to Zululand. Similar resistance to sodium arsenite had been noted in populations of *B. australis* in Australia and *Haematobia hominis* in Brazil.

During the following decade, many instances of resistance were discovered in California, where control measures are usually more intensive than elsewhere. In 1941, only 2 years after the introduction of tartar emetic bait-sprays, a resistant strain of the citrus thrips (*Scirtothrips citri*) was reported from the San Fernando valley, that showed 79% survival as against a normal survival rate of 1%. Similar resistance was also reported from the western Transvaal. In 1943, the gladiolus thrips (*Taeniothrips simplex*) was showing resistance to tartar emetic in certain localities, and in southern California the walnut huskfly (*Rhagoletis completa*) had developed a tolerance to cryolite sprays greatly in excess of what it had 9 years earlier. In 1944, it was apparent that there was a strain of the peach twig-borer (*Anarsia lineatella*) near the town of Empire that was resistant to basic lead arsenate. It showed 20% survival to treatments that normally eliminated all but 3%; it has been suggested that this area-restricted strain is due to a local mutation.

Then in 1946 there first appeared the well-known instances of resistance in the housefly (*Musca domestica*) that have brought the entire subject of insecticide tolerance into the lime-light. In various parts of Italy, including Rome and Naples, adult houseflies were showing resistance to doses of DDT that had completely controlled them when this insecticide was first introduced 2 years previously. Meanwhile in northern Sweden, near the town of Arnas, a DDT-resistant strain was discovered to exist where this insecticide had never been used before. In 1947, a resistant strain was discovered at Ellenville, N. Y., and in this and the following year it became evident that resistant houseflies were present in at least 6 states, and were prominent in Florida and California. No more will be said about DDT-resistant *Musca* at this point, since the topic will be amply covered by succeeding speakers.

Although this problem does not yet appear to be of the importance in mosquitoes that it is in houseflies, instances of DDT-tolerance have been reported for culicine larvae. In 1947 it was established *Culex pipiens* taken from the Pontine marshes south of Rome were more resistant than a normal strain. In 1949, larval populations of the salt-marsh species *Aedes taeniorhynchus* and *A. sollicitans* at Cocoa Beach, Florida, proved to be resistant to DDT treatments which had given complete control throughout the previous 4 years. In 1949 also, both *Culex* and *Aedes* larvae were reported to be resistant to DDT in Kern County, California. A similar instance was afforded by the filter fly (*Psychoda alternata*) in Illinois, where larvae in 1949 were resistant to doses of DDT that had controlled them in the previous 2 years.

Finally, in 1949 resistance appeared in the greenhouse red spider (*Tetranychus telarius*) to parathion, only 1 year after its introduction. The first instance was at Cromwell, Connecticut, where a survival rate of 85% had developed to dosages that completely killed the normal populations. Instances of parathion-resistant red spider are now appearing elsewhere in the eastern United States on greenhouse roses; it should be noted that a similar phenomenon of resistance appeared in 1943 in the case of red spider on flowering plants treated systemically with selenium salts.

It is now a pleasure to call on Dr. H. H. Schwardt of Cornell University to make the contribution to this symposium that he has so kindly prepared.



## RESISTANCE OF HOUSEFLIES TO DDT

H. H. SCHWART

*Cornell University*

In 1914 Melander reported that the San Jose scale was becoming resistant to lime sulphur solution. Quayle in 1916 reported resistance to HCN by the California Red Scale and Black Scale. Hough's famous work in 1928 showed that certain strains of codling moth had developed resistance to arsenicals. Other investigators have observed resistance to certain insecticides in the confused flour beetle, a cattle tick, thrips, screwworm, houseflies, and several species of mosquitoes.

In view of all this literature, it is surprising that no one apparently worried when the widespread use of DDT against the house fly and many other species was begun in 1945. It was a favorable setting for the development of resistance and in the housefly this became apparent in Sweden and Denmark in 1946, in Italy about the same time, and in 1948 housefly resistance to DDT was reported from several sections of the U.S. including New York, Florida, and California. By July of 1949 the DDT recommendation for housefly control was discontinued in several states of the U.S.

Wiesmann in 1947 reported on investigations indicating that resistance in the housefly was due to morphological changes in the tarsi that inhibited the absorption of DDT. Metcalf was unable to confirm Wiesmann's work and indeed discredited it when he showed that resistance was demonstrable when DDT was applied by injection methods.

Sternburg, Kearns, and Bruce presented abundant data showing that resistant flies were able to metabolize DDT into the less toxic metabolites DDE (2,2 bis, parachlorophenyl, 1,1 dichloro ethylene) and DDA (bis, parachlorophenyl, acetic acid), while non-resistant flies were unable to accomplish this. This appears to be the best explanation for resistance so far advanced. The presence of the metabolites DDE and DDA in DDT-treated rabbits had been shown previously by Ofner and Calvery.

March and Metcalf have added support to the detoxification theory by experiments in which resistant and non-resistant strains of houseflies were treated with 1,1 bis parachloro phenyl 2 nitropropane, and 1,1, bis parachlorophenyl 2 nitro butane. These compounds obviously cannot be detoxified by the de-hydro halogenation process through which DDT is metabolized. These compounds are equally toxic to resistant and non-resistant flies. These authors suggest that a DDT additive that will prevent resistant flies from metabolizing DDT should be sought.

The various investigators of the phenomenon of resistance are not in complete agreement on the possibility of the decline of resistance when several generations are reared without treatment. In 1948 King stated that resistance was lowered or lost after about 15 generations out of contact with DDT. Recently the same author withdraws somewhat from this position and reports that resistance may fluctuate in succeeding generations of resistant flies reared out of contact with DDT. Pimental, Schwardt, and Dewey have found that New York strains of resistant flies lose resistance when unexposed to DDT for many generations, but that treatment with lindane, dieldrin, or parathion for several generations does not decrease DDT resistance.

No differences in length of life cycle, or size of stages between resistant and non-resistant strains were found by Barber and Schmitt, or by Metcalf and March. Pimentel however has shown that larvae of resistant flies have a significantly longer cycle than larvae of non-resistant strains. He has also shown that, within a resistant strain, larvae pupating the first 48 hours of the general pupation period produce flies less resistant to DDT than those transforming during the last 48 hours of the period.

Bruce states that resistance may be acquired when only the larval stage is exposed to DDT and that treatment of both larval and adult stages accelerates the rate of development of resistance.

All investigators of the subject apparently agree that flies resistant to DDT can develop tolerances for other insecticides more rapidly than those not resistant to DDT. Pimentel has shown that DDT-tolerant flies can develop significant lindane resistance after only 6 generations of exposure.



## THE RELATION OF SPACE FUMIGANTS TO THE PROBLEM OF INSECT RESISTANCE TO INSECTICIDES<sup>1</sup>

H. A. U. MONRO<sup>2</sup>

*Science Service Laboratory, Department of Agriculture, London, Ontario.*

Fumigants are poisons which reach the exterior of their target, an insect or other harmful organism, in the gaseous condition. Therefore, the problem of the application of these poisons is essentially a physical one. The actual mechanism whereby the fumigant enters the body and reaches its site of toxic action has little or no relation to this first problem of bringing sufficient quantities of the gas into the region surrounding the organism, so that a kill may subsequently be effected. On this physical basis, therefore, fumigants may be divided into two main categories influenced by their field of application; it being understood, of course, that some compounds may be employed in both. In the first class are the highly volatile compounds, the so-called "space" fumigants, which are required for use in structures which can be rendered comparatively gas-tight, such as fumigation chambers, mills, warehouses, railroad cars, ships, tents, and tarpaulins. In the second category are chemicals of low volatility used as soil fumigants and in mill machinery. In such compounds slowness of evaporation and diffusion is often an advantage rather than a handicap. The present review deals exclusively with the problems encountered with space fumigants.

This essential volatility of a poison used to fumigate spaces or to penetrate commodities is associated with a boiling point close to or below prevailing temperatures found in the structures undergoing treatment. This property is necessary in order to achieve the required toxic concentration from the beginning of the exposure period and to ensure that the poison be rapidly aerated from the structure or material after the completion of treatment. This volatility is only exhibited by compounds with low molecular weight, containing a small number of atoms, such as HCN, (hydrocyanic acid gas), CH<sub>3</sub>Br (methyl bromide), SO<sub>2</sub> (sulphur dioxide), H<sub>2</sub>S (hydrogen sulphide), CS<sub>2</sub> (carbon bisulphide), CCl<sub>4</sub> (carbon tetrachloride), and C<sub>2</sub>H<sub>4</sub>O (ethylene oxide). Therefore, on purely mathematical grounds, the number of such compounds is limited, and it is highly probable that all those suitable for this purpose have been investigated at one time or another. When we consider that some of these comparatively simple compounds are ruled out on account of undesirable characteristics such as instability, inflammability, explosion hazards, corrosion of metals, tainting of foods, or destruction of plant material, it is realized that the choice of good fumigants is very limited.

<sup>1</sup>Contribution No. 86, Division of Plant Protection, Science Service, Department of Agriculture, Ottawa.

<sup>2</sup>Senior officer, Fumigation Unit.

This paucity of choice may, therefore, pose serious problems if, in the future, populations of species of insects usually controlled by fumigants develop increased resistance to them. It is the purpose of this review to stress the importance of this problem and to warn that resistant populations may ultimately be produced by the very intensity of our own control measures.

### HISTORY

It is significant that some of the classic instances of developed resistance are concerned with the action of fumigants on insects. The outstanding case, and the one which has been most closely investigated, is that of the control of the California red scale, *Aonidiella aurantii* (Mask.) by HCN. This has been the subject of intensive research by a number of investigators and the results have been reviewed by Smith, Quayle, Babers, and the speaker. It is noteworthy that Quayle reported that strains of this insect, resistant to HCN, were also significantly more resistant to methyl bromide and ethylene oxide than the normal populations. Yust and Busbey also investigated the differential resistance of the two strains to methyl bromide. Although in the mature adults, HCN-resistant strains were also more resistant to methyl bromide than the ordinary strains, in the early gray adult stage this situation was apparently reversed. Lindgren and Gerhardt found no difference between the resistant and non-resistant strains in their susceptibility when fumigated with ethylene dibromide. In the case of the confused flour beetle, *Tribolium confusum* Duv., Gough was able, by a process of selection, to develop a strain resistant to HCN.

### DEVELOPMENT OF RESISTANCE IN QUARANTINE FUMIGATIONS

In a properly conducted plant quarantine fumigation treatment there are presumably no survivors. That this ideal of complete mortality has been attained is constantly demonstrated by post-fumigation inspections. As the material undergoing treatment is continually being drawn from an outside source, to which it is not returned, it is obvious that the problem of development of resistance at the point of origin does not occur. However, there is also a great responsibility placed on the shoulders of those carrying out such treatments. If, through laxity, any small percentage of survival is allowed to occur, the survivors may be exported to some other region, possibly carrying with them the potentiality for increased resistance to fumigants or other insecticides.

Another field which has recently been covered by quarantine authorities is the treatment of plant products in bulk. Also, the empty carriers, such as the holds of ships, are often fumigated before they are loaded with such materials. This work has been widely developed during recent years by the speaker and his associates of the Division of Plant Protection. It has obviously been of great benefit in preventing the spread of large populations of stored product insects not only throughout this country, but, in the case of exported material, to all parts of the world. However, in this respect, the possible future development of insect resistance must not be ignored.

In Table 1 are presented, in summary, data obtained with all stages of the granary weevil employed as test insects, to study the effectiveness of HCN and methyl bromide in the fumigation of the empty holds of ships. It must be emphasized that these figures, while highly indicative, do not represent the survival of the normal insect populations on board the ships. Post-fumigation inspections revealed that the treatments were sufficiently successful to make it very difficult to find survivors from the normal fauna. The data does warn us, however, that some degree of survival is inherent in this type of commercial treatment and that in future we must be constantly on the look-out for the development of insect resistance in this field. Moreover, the fact must not be ignored that the survivors, if any, are being exported from Canada to other parts of the world. Other countries are also conducting control campaigns by fumigation of their plant products destined for export, and from time to time we receive such cargoes.



It is clear that if the more important insects attacking plant products are capable of developing resistance to fumigants, such potentiality is being circulated freely through the commercial channels of the world. This is a much wider field than that concerned with insects attacking a specialized crop grown in a comparatively restricted area, as in the case of the citrus fruits of California.

Table 1.

MORTALITIES OF STAGES OF *Sitophilus granarius* (L.) EXPOSED IN SHIP FUMIGATIONS DURING 1948, 1949, AND 1950 IN MONTREAL, P.Q., AND VANCOUVER, B.C.

Exposure period 10-12 hours

Treatment Data		
Fumigant	HCN	CH <sub>3</sub> Br
Number of ships	17	28
Total space fumigated, cubic feet	2,605,761	7,535,603
Dosage range, lb. per 1,000 cu. ft.	.5 - .75	.5 - 2.0
Temperature range, degrees F.	37 - 73	29 - 83

Mortalities of *S. granarius*

	HCN			CH <sub>3</sub> Br		
	Number Exposed	Number Survived	Percentage Mortality	Number Exposed	Number Survived	Percentage Mortality
Egg	17,660	3,419	80.64	41,651	41	99.90
1st larval instar	85,689	957	99.58	48,565	36	99.93
2nd "	26,135	300	98.85	36,333	29	99.92
3rd "	16,068	412	97.44	46,742	134	99.71
4th "	15,373	1,584	89.70	29,703	1,213	95.92
Pupa	2,731	302	88.94	5,581	274	95.09
Adult	6,077	2,214	63.57	14,775	435	97.06

## FUMIGATION HAZARDS

If carefully conducted by competent persons, a fumigation is far from being a hazardous undertaking. Most operations are undertaken so that no part of the human body is exposed to toxic concentrations of the gas. In some fumigations, such as mill or ship treatments, however, it is necessary for the operators, wearing respirators, to endure brief exposures to fairly high concentrations while the structures are being opened for aeration. At such times protection is usually afforded by the industrial type of respirator (gas mask) fitted with the special canister designed for the type of fumigant being used. However, with all fumigants the dangers of skin absorption cannot be ignored, as has been pointed out in connection with HCN.

Despite the comparative safety of handling fumigants, the fact cannot be ignored that, by reason of fundamental differences between the respiratory mechanisms of mammals and insects, gaseous fumigants are more toxic to human beings than to insects, at the same concentrations and exposure periods (See Table 2).

Table 2.

## ACUTE TOXICITY OF FUMIGANTS TO HUMANS AND INSECTS

FUMIGANT	REMARKS	HUMANS		INSECTS <sup>1</sup> (Shepard et al)	
		Lethal Conc. mg./l.	Exposure hrs.	Median Lethal Conc. mg./l.	Exposure hrs.
HCN	Normal breathing	0.16	1/2 - 1	5.8	5
	Absorption through skin with protection by respirator	20.0 (Anon.)	1/4		
METHYL BROMIDE	Normal breathing	3.0	1/2 - 1	7.4	5
HCN or METHYL BROMIDE	Protection by respirator <sup>2</sup>		1 hour maximum		

The development of races or strains of insects resistant to fumigants will necessitate increasing the concentration of the gas or the length of the exposure period, or both, in order to bring about the desired mortality. An increase in exposure period alone would be attended by a number of possible difficulties in the handling of goods and the availability of structures. In some types of atmospheric fumigation in leaky structures, lengthened exposure periods would lead to the loss of the fumigant below effective concentration. These developments would cause more emphasis to be placed on greater dosage and concentration, thus increasing the hazards to those undertaking the work.

## EFFECT ON FUMIGATED MATERIAL

All fumigants react in certain ways with the material undergoing treatment. In food-stuffs, residues are often formed resulting from the chemical reaction of the gas with the food. In some cases undesirable taints or odours are produced even if the residue is not actually poisonous. At present the fumigants more commonly employed for treating food, such as HCN, methyl bromide, and ethylene oxide can be employed safely at present dosages, but the margin of safety is such, according to Dudley and Neal, that any great increase in dose or exposure period would inevitably bring out fresh problems of aeration and the formation of residues.

In the case of seeds, nursery stock, fruits, vegetables, or actively growing plants, several fumigants such as HCN, methyl bromide, and carbon bisulphide have been used with varying effects on the plant material, but to the speaker's knowledge there are very few insecticidal problems in connection with such materials that cannot be tackled with the aid of one or other of the known fumigants. In all cases, however, great care has to be shown in such treatments and here again the margin of safety could easily be crossed by increase of dose.

## NEED FOR IMMEDIATE INVESTIGATION

From this review it is clear that the development of resistance of some species of insects to important fumigants has been demonstrated. It is obvious that we must be prepared to encounter the same problem with other species in the future. It would be highly desirable if the trend in this direction could be studied in advance in the laboratory so that some basic information may be obtained before the problem is encountered in the field.

<sup>1</sup>*Sitophilus granarius* (L.)<sup>2</sup>Recommendations by manufacturers of fumigants and respirator canisters for exposure to normal fumigation concentrations.

## SUMMARY

1. The number of chemicals which can be successfully employed in the gaseous form to fumigate spaces and penetrate commodities is limited on physical grounds, as only those with comparatively simple molecules can be employed.

2. Development of insect resistance to fumigants has already been demonstrated in several important cases and there is no reason to believe that this phenomenon cannot become more general.

3. In some types of commercial fumigation, in structures not specifically designed for this purpose, some survival of various stages of insect pests is inevitable, and it is in such surroundings that the development of resistant populations must be looked for.

4. If it is found necessary to deal with increased resistance by increased doses of fumigants or prolongation of exposure periods, serious problems of human hazard and damage to perishable material may be encountered.

5. It is clear that advance information on the extent and nature of insect resistance to fumigants will be of value in dealing with such problems if and when they arise.



## MORPHOLOGICAL AND HABIT CHANGES CORRELATED WITH RESISTANCE TO INSECTICIDAL TREATMENT

FRANK O. MORRISON

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Mr. H. S. Smith in his, at that time, almost prophetic paper on racial segregation in insect populations and its significance in applied entomology, referring to variations in physiology said, "These non-visible mutations are just as common and follow the same laws as the visible ones". A review of the literature on insects which have developed strains tolerant to insecticidal treatments certainly suggests that such tolerance is a result of some "non-visible mutation", such as a change in a detoxication mechanism or an enzyme system or in the permeability of integument or cell membranes. Sternburg et al conclude that DDT-tolerant houseflies absorb DDT as readily as non-resistant forms but metabolize it more successfully. There are, however, some workers who report habit or morphological differences in insecticide-resistant forms. I propose to bring together such references. They are few in number and may be classified into: (a) those which refer to changes in habit; (b) those which refer to observed morphological differences, and I am including a third somewhat doubtful category; (c) references to tolerance being a result of increase of general vigour, which although often no specific mention is made of changes in behaviour of structure, would certainly be expected to be accompanied by some such changes.

### INSTANCES OF OBSERVED CHANGES IN HABITS OR BEHAVIOUR

Gray and Kirkpatrick, Pratt et al, Hardman and Craig, and Yust, Nelson and Busbey discovered and studied the well-known phenomenon of protective stupefaction in California red scales, when they are subjected to sublethal dosages of HCN. They also produced evidence that this behaviour was different and more favorable to survival in resistant strains. Hough found that arsenic-resistant codling moth larvae entered fruit sooner after hatching. One might assume that they travelled a shorter distance before entering fruit than did susceptible



strains. King & Gahan observed that DDT-resistant flies in barns were resting on feed-troughs and untreated floors and equipment rather than on treated walls and ceilings. This they attributed to DDT-repellency. Tests with treated grills showed repellency to occur at high dosages only. Personal observations by the reviewer bear out the observations of King & Gahan on the preferred resting places of DDT-resistant races of the housefly, but before postulating either repellency or habit changes, one would have to eliminate the possibility of such flies being intoxicated by sublethal DDT dosages. Certainly they appear sluggish and no mention of such behavioural changes has been made by workers rearing resistant laboratory strains.

#### *INSTANCES OF OBSERVED MORPHOLOGICAL DIFFERENCES.*

Though several investigators studying resistant strains of different insect species have made attempts to find morphological differences between resistant and non-resistant forms, the results have been negative. Gough made a careful study of a normal and an HCN-resistant strain of confused flour beetle reared in the laboratory, but found no morphological differences. Sacca is stated to have given the DDT-resistant housefly strain, which he studied in Italy, a new variety name. His reviewers (the present writer has not had access to the original paper), however, state that he describes no morphological differences. Wiesmann on the other hand, in his studies in Switzerland, devotes a whole section of his paper to morphological differences in his resistant (Arnas) strain. The following is an abbreviated and somewhat liberal translation of that section in part with tables omitted:

##### *"1. Melanin content of the appendages.*

If fresh, normal, unstained legs of both fly strains are examined in water under the microscope the following differences will be found:

Basler strain (non-resistant): cuticle grayish-black in color, hair papillae white, tracheae in the tibia clearly visible, setae dull gray; completely bleached after 26 hrs. in diaphanol.

Arnas strain (resistant): cuticle black, opaque; hair papillae yellowish brown; tracheae in tibiae not visible, setae very black; only completely bleached after 72 hrs. in diaphanol.

The general integument is also more deeply pigmented in the Arnas strain while the tarsal setae are stiffer.

##### *2. Morphology of the tarsi*

Tarsal segments of the prothoracic leg were measured in a number of flies of each strain and averages suggested that they were more nearly equal in length in the resistant strain, the first tarsomere (counting from the apical end) being shorter than in the susceptible strain. The tarsi of the Arnas strain were also broader and generally more sturdy". Unfortunately the author attempted no statistical analysis of his data and the differences shown are very slight.

"The cuticle on the ventral side of the 1st and 2nd tarsomeres of the prothoracic leg was definitely thicker."

Wiesman suggests that the thicker cuticle, denser pigmentation, stiffer bristles, and the relatively smaller size of the first tarsomere in the resistant strain are associated with the acquiring and adsorbing of less DDT from residues on surfaces.

#### *INSTANCES OF A GENERALLY GREATER VIGOUR AND RESISTANCE TO OTHER CHEMICALS AND ENVIRONMENTAL HAZARDS.*

Melander, who is credited with first observing resistant-strain phenomena in the San Jose scale, found no evidence that lime-sulphur resistant forms had any especial tolerance of oil. Quayle suggested that HCN-resistant California red scale displayed resistance to other fumigants and oil, while Lindgren and Dickson, and Cressman deny the resistance to oil. Lind-

gren & Gerhardt found no resistance to ethylene dibromide, and Munger reports no difference between California red scale strains in reproductive ability, normal mortality or developmental time. Hough produced considerable evidence for the theory of increased general vigour in arsenic-resistant codling moth populations. The arsenic-tolerant strain was shown to be tolerant of many other insecticides including some fumigants and it was even more difficult to starve than the normal strain. Babers cites B. R. Bartlett as having selected out DDT-, tartar emetic- and HCN-resistant strains of *Drosophila* and finding the HCN-resistant strain resistant to diethyl ether, exposure to cold, and anaesthesia, while the DDT-resistant strain was resistant to the fluorine analogue of DDT and to HCN.

Knipling reported on screwworms resistant to phenothiazine, but not to certain other chemicals. Garman reporting on parathion-resistant red spider, speaks of adequate control by tetraethylpyrophosphate.

Reports on DDT-resistant houseflies are conflicting. Various workers report strains with different degrees of resistance to DDT analogues but no general resistance, others report generally increased vigour. The following is not a complete list of references to cross tolerances but indicative of the general findings. Wilson & Gahan considered their stock of DDT-resistant flies as an unusually strong one, resistant to several insecticides. March and Metcalf found DDT-resistant flies resistant to BHC and to Compound 497. Barber et al found their stock resistant to DDT and methoxychlor only.

Blickle et al found DDT- and thiocyanate-resistance doubled in a strain accidentally exposed to benzene hexachloride. Barber and Schmitt interbred the tolerant and susceptible strains to prove them conspecific. Their resistant strain showed high resistance to DDT and analogues, but no resistance to other insecticides. The pupal weight of the resistant strain was slightly lower and the pupal mortality higher, which does not seem to indicate high vigour. Babers considers their conclusion about resistance to other insecticides unwarranted from the data presented.

Barber selected out fly strains with different pupal shapes, and Starnes states that six pupal types were recognized, occurring in different proportions in twenty-one strains reared. Though three were resistant strains and two were highly susceptible, no correlation with pupal type and resistance has yet been suggested.

Barber et al claimed to have developed strains resistant to pyrethrum and to an unnamed botanical extract but not to DDT. The resistant strains had heavier pupae. Pratt and Babers selected out strains resistant to DDT and resistant to a mixture of insecticides, then tested cross resistances to individual materials. The authors do not deny the existence of specific resistance but suggest that a high degree of the resistance encountered is of a general nature and probably indicative of increased vigour. Wiesman found that his resistant strain of flies in Switzerland were more slowly affected by and less susceptible to high temperatures, more slowly affected by cold and more resistant to it, took longer to be anaesthetized by methyl acetate and almost twice as long to regain activity. It is interesting to note in this connection that Bucher et al were unable to select out a stock of houseflies with increased pupal resistance to cold.

I opened the discussion with a quotation from the H. S. Smith paper, I should like to close it with another one from the same source, dealing with the supposed increased general vigour of Hough's arsenic-resistant codling moth race: "If, however, the Colorado race is superior to others in its resistance to so many kinds of unfavorable environmental influences . . . it is difficult to understand why this superior race has not become dominant everywhere regardless of the application of arsenicals". This statement is later qualified by the suggestion that if the more vigorous race should prove to have a lower reproductive potential (which appears to me unlikely) the situation is theoretically understandable.

## SELECTION FOR DDT TOLERANCE IN *MACROCENTRUS ANCYLIVORUS*\*

D. P. PIELOU,

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I need hardly mention the concern with which biological control specialists view extensive insecticidal operations, because destruction of beneficial parasites may in the long run produce a situation worse than that which existed in the first place.

Since, however, it is now clear that resistance to DDT and other insecticides can develop in pest insects, it is a fairly obvious approach to the problem to attempt to produce resistant strains of beneficial parasites. The production, release and successful establishment of such strains might do much to solve the contradiction involved in simultaneous chemical and biological control measures.

From the practical point of view, in this project, we are concentrating our efforts, at Belleville, on an attempt to produce a DDT-resistant strain of *Macrocentrus ancylovorus*. This well known parasite attacks, and is a formidable enemy of, the Oriental Fruit Moth in North America.

In Canada, this parasite was introduced into the Niagara peninsula of Ontario in 1929, and is generally considered to have saved the peach growing industry there, which had been threatened by the appearance of the Oriental Fruit Moth about four years earlier. Today extensive spraying operations, introduced to supplement the control afforded by this parasite, are a danger to its existence. The value of a resistant strain is obvious.

From the purely theoretical point of view *Macrocentrus* is not a very good insect for this sort of experimental investigation. The insect is reared by the method of Finney, Flanders and Smith—an elaborate and rather expensive procedure involving bulky equipment and taking up much laboratory space and time. It is a continuous "conveyor belt" process; at one point egg-laying parents are added each day, and at another, the day's crop of young *Macrocentrus* is taken off. This breeding unit cannot be replicated with the space and labour at our disposal. Therefore we cannot, as we would like to, breed up independent stocks, each differently treated, and cross these various stocks in order to make a genetic analysis.

Our operations are confined to selection alone, a continuous daily selection, performed on our one large continuous breeding unit. I may add that parallel theoretical studies are being made on *Drosophila*, in which case, we are able of course, to rear as many differently treated stocks as we please.

Before commencing selection we therefore made an extensive determination, involving over 50,000 insects, of the DDT-resistance characteristics and other physical characteristics of survival of this original ancestral stock. These data provide a standard of reference for future observations. Once selection is underway we are changing the characteristics of the insects and we cannot go back to the original stock.

In order to carry out our DDT tests, and selection, on large numbers of insects quickly and conveniently, a new technique was developed for making thin crystalline films of DDT in a celloidin base on glass plates. Films deposited from ordinary solvents frequently leave deposits which crystallize irregularly and only in places; elsewhere the DDT may be present

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\*Verbatim report of a Contribution to a Symposium on the "Development of Resistance in Insects to Insecticides" at the 81st Annual Meeting of the Entomological Society of Ontario, November, 1950.



in a supersaturated or amorphous form which is likely to crystallize out as insects walk across it. The method devised, described elsewhere, provides films which have a known and specified amount of DDT in a given area, uniformly distributed and unquestionably crystalline.

Extensive data have been obtained on the DDT-resistance of the original laboratory stock using different times of exposure to such films (from 1 to 8 minutes) and different concentrations of the crystalline films (from 23 to 69 micrograms per sq. cm.).

Evaluation of mortality has been made not at one specific time after treatment but at intervals throughout the major part of the life period of the species. (The species is short lived and very few adults live to be 15 days old).

It is evident from the data that the effect of the DDT is complete within 40 hours; after that time any further mortality is due to natural death. The effect of DDT is, then, to produce a high early life (or young adult) mortality—since we conduct our experiments always on one age group—on those newly emerged adults less than one day old.

In the case of all but the highest DDT intensities there is then a "tail" of survivors.

These survivors are naturally fewer in number than in the controls but an examination of the daily death rate (that is the proportion: the number dying in one day to number alive at the beginning of that day) shows them to be dying more slowly than those in the controls.

In other words even under catastrophic conditions of selection (not the best condition) destruction of the population is not random; the survivors, presumably tougher towards DDT, are also longer lived.

We hope that this selected variation contains a genetic element, for it is this tail of survivors that we use in the selective breeding experiments which have followed this quantitative description of the DDT characteristics of the original stock.

Our selection experiments, which have involved over 100,000 insects to date, have been continued daily (for some 90 days so far) and over more than four overlapping generations in the continuous breeding unit; DDT selection of parents has been made each day, 7 days a week, from our daily crop of 1000–2000 insects.

Using a standard film concentration of 23 micrograms per sq. cm. and an exposure time of three minutes, our survival has increased from an average around 30% daily to 90% daily (making evaluation 40 hours after exposure) comparable with the figure for control survival in our original tests.

We now need to use a film of 69, instead of 23, micrograms per sq. cm. for three minutes to reduce survival again to the 30% level. We may say therefore that the selected stock is at present roughly three times more resistant than the original laboratory stock.

We regard this rapid increase in survival as most promising and we are now increasing our exposure concentration and continuing our selection at the increased dosage.

We cannot say, at present, how often we shall be able to increase dosage in this way and continue selection—but presumably a time will come when we have selected a pure line, with maximum resistance to DDT, and upon which selection will have no further effect.

This will be the time to breed up the resistant stock on a large scale and make mass releases against the host insect.

## THE DEVELOPMENT OF RESISTANCE OF INSECTS TO INSECTICIDES

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The unwanted selection of resistant strains is a potential danger of all insect control measures, whether chemical, cultural or by the use of resistant varieties of host plant. The appearance of biologic forms able to attack his resistant varieties is a constant threat to the plant breeder; crop rotation favours the survival of strains of longer resting period. For these reasons, an attack on the chemist such as that made by Wigglesworth in his presidential address to Section D of the British Association is unrealistic and, if anyone is to be blamed for the development of insecticide resistance, it is the entomologist who has advocated the widespread use of a single insecticide without regard to ecological consequences.

The problem of the resistant strain should serve only for the encouragement of research on its origin and prevention. Among several lines along which this research could proceed are:

(1) the elucidation of the genetical basis of the development; (2) studies of the mechanisms whereby tolerance to the insecticide is achieved and of the inhibition of these mechanisms; (3) the selection of insecticides to which a given insect population shows a low degree of variability; (4) the selection of contrasted pairs of insecticides such that those individual insects resistant to the first are susceptible to the second, and vice versa, whereby the survivors of the treatment are those of the intermediate resistance and their progeny will have no preponderance of the resistant genes.



## CONCLUDING REMARKS

A. W. A. BROWN: This brings us to the end of our list of chosen speakers, and time is running out. I would like to call on certain others, such as Professor Baker and Mr. Ross, to say a few words, but I am not going to do it. Instead, as a token of the general discussion which we had hoped to have, may we call for just one question from the floor.

Visitor from Pakistan: I have been much interested in these presentations but I am confused. Conflicting statements have been made — what message on the subject can I take home with me?

A. W. A. BROWN: We can certainly sympathize with your feelings, sir. There are so many features in the resistance problem which are inconsistent. In the first place, after hearing several submissions today one would be inclined to doubt whether DDT-resistance in houseflies actually existed; whether it was not just a matter of comparing healthy vigorous wild flies with a laboratory strain in which all the runts and other inferior genotypes had been allowed to survive. Certainly it would appear reasonable to conclude that cases of a slightly increased level of DDT-resistance in field populations as compared to laboratory strains may be ascribed to this cause.

In the second place, there is the vexed question of reversion or loss of resistance in successive generations withheld from DDT treatments. If the factors of resistance are genetic, as opposed to cytoplasmic factors or characters acquired from the environment, the level of resistance should axiomatically be maintained in the stock. And so it was with pleasure that we heard that, despite the reversion in the DDT-resistant stocks found in the Savannah labor-

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<sup>1</sup>Director

atory, the DDT-resistant strains in California (such as the Bellflower) maintained the level for several generations. Now Dr. Schwardt has given us the sad news that the California strains do eventually show reversion, while the several strains maintained at Orlando have shown fluctuations in resistance. The most satisfactory explanation for these results from the genetical standpoint is to presume that the resistant strains, when collected in the field, had not yet attained complete homozygosity for the genes responsible for resistance.

In the third place, there is the question of whether a single gene or multiple genes are involved. Evidence so far suggests that the factor or factors for DDT-resistance in houseflies do not show dominance, since the hybrids (normal x resistant) are intermediate in resistance. There is no sex linkage, since reciprocal crosses are identical. Bruce and Decker in Illinois conclude that the fact that the hybrids show a greater variability than either parent strain constitutes evidence that resistance involves multiple genes. However Miss Harrison at the London School of Hygiene has evidence of clear segregation in the  $F_2$  generation of hybrids, which would indicate that single or few genes are concerned. Nevertheless, both the Orlando and the Illinois workers have found that in artificially-induced resistant strains the full resistance is not obtained until approximately the 20th generation; if this is taken as the time necessary to attain full homozygosity, it is good evidence that multiple genes are involved.

In the fourth place, there is the question of the physiological causes of resistance. It must be stressed that the terms physiological and genetic are not mutually exclusive; indeed every physiological character has its foundation in a genetic factor. The evidence suggests that there may be various causes of resistance to DDT by houseflies. In the Arnas strain it was associated with thicker tarsal cuticles, which however proved not to be the case in the American strains studied at Cornell. In the Cornell strains it has been associated, as Dr. Schwardt has found, with a greater size and vigour connected with a longer larval period. In the Illinois and California strains it was associated with a greater ability to detoxify DDT by dehydrochlorinating it to DDE, and in the Ellenville strain to a higher cytochrome oxidase activity. It has been suggested by Bruce and Decker that a change in roosting habits of the houseflies may be a factor in conferring apparent resistance to residual sprays of DDT.

The rapid rise of DDT-resistant strains of houseflies has thus focussed attention on the many-sidedness of the problem of insect resistance in response to insecticides. On the physiological side it may be due to differences in habit, cuticle, enzymes, or general vigour, or to combinations of any of these factors. On the genetical side, single, few or multiple genes may be involved. Moreover, the same species may well respond to the same insecticide in different ways in different areas. The overall problem is a challenge to the breadth and depth of the entomologist's training and ability as an investigator.



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## RESULTS OF SPRAYING FOR THE CONTROL OF THE ORIENTAL FRUIT MOTH, *GRAPHOLITHA MOLESTA* (BUSCK), IN ONTARIO, 1946-1950<sup>1</sup>

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After a long period in which the oriental fruit moth, *Grapholitha molesta* (Busck), had caused comparatively little injury, a severe infestation did considerable damage to peaches in the Niagara Peninsula in 1945. Some preliminary experiments in the fall of that year indicated that DDT might be of value in its control, and in 1946 and subsequent years extensive trials were carried out, both in the Niagara Peninsula (Lincoln and Welland counties) and in southwestern Ontario (Essex County).

The present paper deals only with the direct effect of sprays upon the oriental fruit moth. Parallel studies on the influence of the insecticides upon the fauna of peach orchards have been carried on since 1946, and a considerable amount of data has been accumulated on the effects on other peach pests and on their biological control factors; but this will not be reported until more information has been obtained.

### STATUS OF THE INFESTATION, 1946-50

In general, the oriental fruit moth caused only light to moderate injury in 1946, except in a small group of orchards near Port Dalhousie, where second-generation larvae severely injured the fruit. A general increase occurred in 1947 in both the Niagara Peninsula and southwestern Ontario, although injury was not particularly severe except in a very heavily infested strip along the shore of Lake Ontario from Jordan Harbour to Grimsby Beach.

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The infestation increased still further in 1948, and in most of the peach-growing areas of Ontario the moth caused more injury than at any other time since its discovery in 1925. Injury on Elberta peaches averaged 42.3 per cent in unsprayed plots in the Niagara Peninsula. Where DDT was thoroughly applied losses were greatly reduced, but far too much injury occurred in many orchards, especially where sprays were applied only against the third generation.

In 1949 the population of the moth dropped greatly throughout the province, the average injury on unsprayed Elbertas in the Niagara Peninsula being approximately 9 per cent. A further decline occurred in 1950. Although part of the reduction during 1949 and 1950 was due to the use of DDT in practically all orchards, climatic factors and parasitism were also responsible.

#### *TIMING SPRAY APPLICATIONS*

The oriental fruit moth has three generations and sometimes a partial fourth each year in Ontario. First-generation larvae confine their feeding largely to the twigs in late May and June. Second-generation larvae feed in July and early August in both twigs and fruit, the latter sometimes being attacked by partially grown larvae that leave hardening twigs. Few newly hatched larvae can enter the hard, green fruit in July. The third generation, and the fourth, if present, feed during the rest of the season almost entirely in the fruit, at the time of year when it is softening and readily permits entrance of the larvae.

From this knowledge of the life-history, it was concluded that the number of DDT sprays would vary with the particular generation to be controlled. Three or more sprays would be needed to protect the rapidly growing twigs from first-generation larvae; one or more to protect twigs and fruit from the second generation; and one or two sprays to protect ripening fruit from the third generation. Preliminary experiments elsewhere indicated that three weeks before harvest was as late as DDT could be applied to peaches without leaving too much toxic residue. The arrangement of the applications in the experimental schedules is outlined in Table I. The schedules including sprays for second-generation larvae were applied in their entirety only to late varieties, including Elberta and the 'V' varieties Vedette, Veteran, and Valiant. On earlier varieties the last one or two applications were omitted. The modification of schedules to cover peach varieties ripening over seven weeks or longer has been very difficult. The intervals between applications were sometimes altered when moth development was advanced or retarded by temperature changes. Emergence of moths in the insectary and catches in bait pails were used to determine the periods of flight.

Throughout the experiments the objective has been an economically sound spray schedule that would give commercial control of the oriental fruit moth and at the same time do as little harm as possible to the biological complex of parasites and predators of the moth and of other peach pests. It was assumed from the beginning, and it has been confirmed by field experiments, that the earlier and the more frequently DDT is applied the greater is the danger of upsetting the biological balance in the orchards.

As it was thought in 1946 that the outbreak would soon subside and that parasites and climatic factors would continue to provide the chief protection against severe injury, as they had in the past, experiments at first were confined to tests against third-generation larvae attacking late varieties, especially Elberta. Injury from this generation is particularly objectionable because many of the infested fruits do not bear any obvious external symptoms. Fruit with this so-called invisible injury cannot be culled out during packing, and as it reaches the consumer it has a very serious effect on the sale of peaches. Spraying for first- and second-generation larvae was purposely avoided, primarily because of the possible injurious effect it might have on the parasites of the moth. Also, the amount of early injury then prevalent did not appear to justify the cost of additional sprays. However, as the severity of attack continued to increase from 1946 to 1948, the loss from second-generation injury became very serious and the investigations were expanded to include sprays for the control of the earlier generation. Others of the newer insecticides were also tested.

Table I  
TIMING OF SPRAYS IN EXPERIMENTAL SCHEDULES  
FOR ORIENTAL FRUIT MOTH CONTROL  
IN ONTARIO, 1946 TO 1950

Schedule	Timing of sprays for indicated generation		
	First	Second	Third (Fourth*)
A	0	0	(1) 3-4 weeks before harvest
B	0	0	(1) 6 weeks before harvest (2) 3 weeks before harvest
C	0	(1) Just before peak flight	(1) 6 weeks before harvest (2) 3 weeks before harvest
D	0	(1) 3-4 days before peak flight (2) 2 weeks later	(1) 3-4 weeks before harvest
E	0	(1) 6-7 days before peak flight (2) 10-13 days later (3) 10-13 days after (2)	(1) 3-4 weeks before harvest
F	(1) Petal-fall (2) Shuck-split (3) Shuck-fall (4) 10 days later	(1) 3-4 days before peak flight	(1) 6 weeks before harvest (2) 3 weeks before harvest
G	(1) Shuck-split (2) Shuck-fall (3) 10 days later	(1) 3-4 days before peak flight (2) 2 weeks later	(1) 3-4 weeks before harvest

The effects of the insecticides on the parasites of the oriental fruit moth will be treated in later papers. However, it may be said here that the extensive use of DDT by growers against second- and third-generation larvae in practically all bearing peach orchards for two seasons has had no detectable effect on parasitism by the most important species, *Macrocentrus ancylivorus* Rohw.

#### METHODS AND MATERIALS

Most of the experimental plots contained from 25 to 100 trees (one-quarter to one acre). In one orchard each plot contained five trees and in another about 250 trees. It was not always possible to replicate the plots because few peach orchards contain large blocks of one variety.

All sprays were applied from the ground with conventional power sprayers unless otherwise stated. Approximately three to six gallons were applied per tree, depending on the size of the latter. Wettable sulphur and various acaricides were added to certain applications in some plots, but as they did not have any obvious effect on oriental fruit moth control they will not be listed.

The quantities of materials given are those for the amounts of the complete formulation per 100 gal. of spray. Specifications of the materials were as follows:—

*DDT*.—Fifty per cent wettable powder, from various sources.

*Prathion*.—Fifteen or 25 per cent wettable powder, from various sources.

*Ethyl p-nitrophenyl thionobenzenephosphonate* (EPN-300).—27 per cent wettable powder.

E. I. duPont de Nemours & Co., Wilmington, Del.

\*Fourth generation present in appreciable numbers only in 1949.

## DDT FOR CONTROL OF FRUIT INJURY

## EXPERIMENTS WITH DDT AGAINST THIRD-GENERATION LARVAE ONLY

1946.—Duplicated one-acre plots of Elberta in two orchards in the Niagara district were given two third-generation sprays approximately six and three weeks before harvest. Each application contained 2 lb. of 50 per cent DDT per 100 gal.

The results, given in Table II, showed that DDT had been effective in reducing the amount of late injury and especially the externally invisible injury, in orchards with comparatively light infestations. The first application appeared to be poorly timed, for very few moths were caught in bait pails until after the last spray.

Table II

## EFFECTIVENESS OF DDT IN THE CONTROL OF THIRD-GENERATION LARVAE OF THE ORIENTAL FRUIT MOTH IN ELBERTA PEACHES, 1946

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Total fruit	Percentage fruit injury				Percentage reduction in injury
				Old	New	'Invisible'	Total	
Orchard 1								
A	2	Aug. 5 & 26	5,826	5.8	0.3	0.5	6.5	62.5
B	2	Aug. 5 & 26	6,604	6.2	0.3	0.3	6.8	60.8
C Check	0	—	6,501	7.4	3.6	6.3	17.3	—
Orchard 2								
A	2	Aug. 3 & 22	3,652	4.5	0.4	0.7	5.6	69.0
B	2	Aug. 3 & 22	4,334	4.1	0.3	1.2	5.6	69.0
C Check	0	—	3,412	3.9	3.1	10.9	18.0	—

1947.—The same treatments were applied to the plots used in 1946. The control, as measured by the reduction in injury in the treated plots (Table III), was slightly better than in 1946. The general level of the infestation, however, was so much higher that the injury in the sprayed plots was too great to be considered good commercial control, especially as six to seven per cent of the fruit carried 'invisible' injury that could not be culled out.

Table III

## EFFECTIVENESS OF DDT IN THE CONTROL OF THIRD-GENERATION LARVAE OF THE ORIENTAL FRUIT MOTH IN ELBERTA PEACHES, 1947

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Total fruit	Percentage fruit injury				Percentage reduction in injury
				Old	New	'Invisible'	Total	
Orchard 1								
A	2	Aug. 7 & 27	886	4.0	0.6	6.0	10.5	75.2
B	2	Aug. 7 & 27	1,925	3.3	0.8	7.2	11.3	73.4
C Check	0	—	1,007	8.9	2.9	30.6	42.4	—
Orchard 2								
A	2	Aug. 9 & 25	5,433	4.3	1.4	6.8	12.7	71.1
B	2	Aug. 9 & 25	5,159	3.3	1.3	6.9	11.5	73.8
C Check	0	—	4,073	5.6	6.6	31.9	43.8	—



Records of moth flight again suggested that the first application had been of little value.

Also, a number of tests were run by growers under the supervision of officers of the laboratory. The results generally agreed with those from the two experimental orchards although many of the growers did not spray nearly so thoroughly as the laboratory staff and consequently failed to get as good control. It was evident from both the experimental trials and the growers' experience that third-generation sprays alone could not cope with heavy infestations and that additional sprays against the second generation were also necessary in this area.

#### EXPERIMENTS WITH DDT AGAINST SECOND- AND THIRD-GENERATION LARVAE

1948.—The alarming increase in populations of the moth led to an expansion of the investigations in 1948, four schedules being tested in eight orchards in the Niagara Peninsula. The results are given in Table IV.

Table IV

#### EFFECTIVENESS OF DDT SPRAYS AGAINST THE SECOND AND THIRD GENERATIONS OF THE ORIENTAL FRUIT MOTH ON ELBERTA PEACHES, 1948

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
					Old	New	'Invisible'	Total	
Orchard 1									
A	2	Aug. 26	3rd	3,141	12.4	0.9	7.8	21.1	67.2
B Check	0	—	—	1,943	19.1	4.9	40.3	64.3	—
Orchard 2									
A	2	Aug. 5 & 24	3rd	5,011	6.0	0.6	1.8	8.4	49.1
B	2	Aug. 5 & 24	3rd	4,576	7.2	0.6	1.9	9.7	41.2
C Check	0	—	—	3,344	6.6	0.9	9.0	16.5	—
Orchard 5									
A	2	Aug. 25	3rd	1,168	15.3	1.1	7.6	24.0	22.6
B	2	Aug. 3 & 25	3rd	1,014	18.3	1.8	7.1	27.7	10.7
C	2	July 15	2nd						
	2	Aug. 3 & 25	3rd	1,678	6.7	0.7	2.7	10.1	67.5
D Check	0	—	—	1,776	17.2	1.9	11.9	31.0	—
Orchard 6									
A	2	Aug. 9 & 25	3rd	2,208	8.5	0.6	4.0	13.1	30.3
B	2	July 15	2nd						
	2	Aug. 9 & 25	3rd	1,972	4.6	0.4	0.5	5.5	70.4
C Check	0	—	—	2,329	9.6	0.8	8.1	18.5	—
Orchard 3									
A	2	Aug. 19	3rd	1,753	12.5	1.0	4.3	17.2	55.7
B	2	Aug. 2 & 19	3rd	1,276	20.0	0.5	2.1	22.6	43.7
C	2	July 15	2nd						
	2	Aug. 2 & 19	3rd	2,048	5.5	0.4	1.5	7.4	81.5
D Check	0	—	—	1,526	21.6	1.2	17.3	40.1	—

Table IV cont'd.

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
					Old	New	'Invisible'	Total	
Orchard 4									
A*	2	July 10 & 20	2nd	—	—	—	—	—	—
	2	Aug. 25	3rd	3,436	4.9	0.5	5.2	10.6	80.1
B*	2	July 15	2nd	—	—	—	—	—	—
	—	Aug. 4 & 25	3rd	3,542	8.2	0.9	3.3	12.4	76.6
C Check	0	—	—	1,990	32.8	5.1	15.2	53.1	—

The value of one versus two sprays for the third generation may first be considered. Orchard 1 may be compared with orchard 2; in orchard 5, plot A with Plot B; and in orchard 3, plot A with plot B. In each case one spray gave better control than two, an anomaly due to plot-to-plot variation in infestation.

The reduction in injury given by third-generation sprays alone varied from approximately 11 to 67 per cent, much too small to prevent serious losses from the high infestation prevalent in 1948. Where one application against the second generation was used in addition to the third-generation treatments, as in orchard 5, plot C; orchard 4, plot B; and orchard 3, plot C, control was greatly increased. The reduction in injury ranged from 67.2 to 81.5 per cent; and the total injury varied from 5.5 to 12.4 per cent.

There was no direct comparison of one and two second-generation sprays with the same number of third-generation sprays in each case. In orchard 4, two second-generation sprays plus one for the third generation (plot A) gave somewhat better control than one second- and two third-generation sprays (plot B).

1949.—The results of experiments in which DDT was used against fruit-infesting larvae are given in Tables V and VI. Orchard 8 (Table V) was situated in the Niagara district, and orchard 11 (Table VI) was the Science Service orchard at Harrow in southwestern Ontario.

Table V

EFFECTIVENESS OF SPRAYS OF DDT AND PARATHION  
AGAINST THE SECOND AND THIRD GENERATIONS OF THE  
ORIENTAL FRUIT MOTH; ORCHARD 8, NIAGARA PENINSULA, 1949

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	'Invisible'	Total	
Variety Elberta (averages for duplicate plots)										
A1 & A2	2	—	June 27 & July 13	2nd						
	1½	—	Aug. 15	3rd	2,802	2.6	0.4	1.7	4.7	61.2
B1 & B2	2	¾	June 27 & July 13	2nd						
	1½	—	Aug. 15	3rd	2,379	1.7	0.2	1.9	3.8	68.5
C1 & C2	2	—	June 27, July 9 & 18	2nd						
	1½	—	Aug. 15	3rd	2,682	0.9	0.4	0.3	1.6	95.1

\*Average of 2 plots.

Table V cont'd.

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	'Invisible'	Total	
D1 & D2	2	—	June 27	2nd						
	2	¾	July 9 & 13	2nd						
	1½	—	Aug. 15	3rd	2,920	1.8	0.2	0.5	2.6	78.5
E1 & E2										
Check	—	—	—	—	2,671	5.3	1.3	5.4	12.1	—
<i>Varieties Vedette and Veteran (averages for duplicate plots)</i>										
A1 & A2	2	—	June 27 & July 13	2nd						
	1½	—	July 27	3rd	3,493	3.0	0.2	0.5	3.8	72.5
B1 & B2	2	¾	June 27 & July 13	2nd						
	1½	—	July 27	3rd	2,893	1.6	0.2	0.4	2.2	84.2
C1 & C2	2	—	June 27, July 9 & 18	2nd						
	1½	—	July 27	3rd	2,639	2.0	0.3	0.7	3.0	78.3
D1 & D2	2	—	June 27	2nd						
	2	¾	July 9 & 13	2nd						
	1½	—	July 27	3rd	2,289	3.1	0.2	1.3	4.6	66.7
E1 & E2										
Checks	—	—	—	—	3,147	5.5	3.6	4.7	13.8	—

Only one third-brood application was used in each case. The amount of DDT in this spray was reduced to 1½ lb. to avoid excessive residue on the fruit. This rate was not directly compared with the former one of 2 lb., but it gave reasonably good control of 'invisible' injury in all plots except the Valiant variety in plot E, orchard 11 (Table VI).

Three sprays directed against the second generation were decidedly more effective than two in orchard 8 on Elberta (Table V) but not on 'V' varieties. The use of parathion as an acaricide in some of the plots will be discussed later, but it obviously did not increase the degree of fruit moth control over that given by DDT alone.

Table VI

EFFECTIVENESS OF DDT SPRAYS  
AGAINST THE SECOND AND THIRD GENERATIONS OF THE  
ORIENTAL FRUIT MOTH IN ORCHARD 11, SOUTHWESTERN ONTARIO, 1949

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury	
					Old	New	'Invisible'	Total		
Variety <i>Elberta</i>										
A	2	June 24, July 5 & 18	2nd							
	1½	Aug. 15	3rd	2,012	0.5	0.2	0.0	0.7	97.5	
B	2	June 28 & July 13	2nd							
	1½	July 25	2nd							
	1½	Aug.	3rd	1,646	1.3	0.1	0.0	1.4	90.5	
C	2	June 24, July 5 & 18	2nd							
	1½	Aug. 15	3rd	1,647	1.2	0.1	0.0	1.3	90.8	



Table VI cont'd.

Plot	DDT 50%, lb. per 100 gal.	Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
					Old	New	'Invisible'	Total	
D	2	June 28 & July 18	2nd						
	1½	Aug. 15	3rd	1,660.	1.3	0.5	2.4	4.2	86.2
E	1½	Aug. 15	3rd	885	5.0	1.6	0.0	6.6	79.4
F									
Check	—	—	—	1,671	8.6	5.2	16.6	30.4	—
<i>Variety Valiant</i>									
A	2	June 24, July 5 & 18	2nd						
	1½	July 25	3rd	1,734	0.5	0.2	0.0	0.7	97.2
B	2	June 24, July 5 & 18	2nd	1,277	0.9	0.1	0.0	1.0	95.9
C	2	June 28 & July 13	2nd						
	1½	July 25	3rd	1,857	2.1	0.9	1.5	4.5	81.1
D	2	June 28 & July 13	2nd	1,752	2.5	1.1	1.4	5.0	79.0
E	1½	July 25	3rd	1,281	3.0	1.1	5.5	9.6	59.6
F									
Check	—	—	—	1,310	5.5	3.7	14.5	23.7	—

In orchard 11, in southwestern Ontario, the three second-generation sprays were superior to two on all varieties. It should be noted that the development of the moth is usually a few days earlier in southwestern Ontario than in the Niagara Peninsula; hence the sprays in orchard 8 on June 27 and in orchard 11 on June 24 were applied at approximately the same stage of development. When the timing was altered from that for the basic schedule E (Table I) used in plot A, control was generally poorer; the omission of one or more applications also lowered the degree of control in most cases.

In both orchards all schedules containing two second-generation sprays (in addition to a spray for the third generation) gave good commercial control, even if they were not always quite so effective as schedules with more sprays. A schedule with two second-generation and one third-generation spray of DDT was very effective also in the other experimental orchards, where they were not compared directly with four-spray schedules (Table VIII).

1950.—The low infestation in some of the experimental orchards in 1950 made the results of doubtful significance, and some of the data have been discarded. Records of fruit injury are given in Table VIII. The use of parathion in a number of plots will be discussed later.

In two orchards the amount of DDT in the third-generation spray on Elberta was reduced to 1 lb. 'Invisible' injury, the best criterion of the efficiency of this application, in one orchard was 0.3 per cent in the sprayed plot and 10.9 per cent in the check; and in the other orchard these values were 0.4 and 6.9 per cent respectively. This degree of control is comparable to that generally obtained from 1½ lb. of DDT where the intensity of attack is similar.

Only two DDT sprays were used against the second generation in any of the plots in 1950; the control was satisfactory in most cases.

#### DDT SPRAYS AGAINST FIRST-GENERATION LARVAE

In 1948 a number of growers in the Vineland-Jordan area of the Niagara Peninsula followed a so-called eradicator program of seven DDT sprays, recommended by a local fruit growers' co-operative association. This schedule included four sprays for the first generation, one for the second, and two for third (Table I, schedule F). The first- and second-generation sprays

were to be applied on both young and bearing trees. The schedule recommended by the Niagara Peninsula Spray Service for the same year consisted of one spray for second- and two for third-generation larvae (Table I, schedule C).

In 1949 and 1950 some growers continued to apply the early sprays for the first generation, although the first, or petal-fall, spray was omitted. The Spray Service schedule for both these years called for two sprays for the second generation and one for the third (Table I, schedule D).

It is difficult to assess the value of the early eradicator program experimentally because it naturally reaches its greatest efficiency when used over large areas; small orchard plots are of little value. In 1949 a six-acre block of Elbertas was divided into two plots; one received the standard schedule of two second- and one third-brood sprays and the other plot was given three additional sprays for the first generation. The experiment was repeated in the same plots in 1950. Results are given in Table VII (orchard I).

To supplement the meagre experimental data, records of fruit injury from a number of orchards sprayed by the owners have also been assembled in Table VII. The limitations of such records must be borne in mind; the variations in the degree of control in any one year follow from differences both in the infestations and also in the efficiency of spraying. The decline in severity of injury over the three years is largely due to the natural decline in the general infestation, although the cumulative effect of the treatments may have played a small part.

Table VII

COMPARISON OF FIRST- TO THIRD-BROOD SCHEDULES (6 or 7 DDT SPRAYS)  
AND SECOND- AND THIRD-BROOD SCHEDULES (3 DDT SPRAYS)  
IN THE CONTROL OF THE ORIENTAL FRUIT MOTH

Orchard and locality	Variety	Percentage total fruit injury		
		1948	1949	1950
<i>Six or seven DDT sprays</i>				
1. Vineland (Experimental)	Elberta	—	0.4	0
2. Vineland	Mid-season	42.2	0.4	0
	Elberta	22.8	0.3	0
3. Vineland	Mid-season	2.4	0.0	0
	Elberta	0.5	3.0	0
4. Vineland Station	Mid-season	13.3	1.0	0
	Elberta	8.6	—	1.3
5. Jordan Harbour	Mid-season	1.2	0.7	0
	Elberta	1.9	—	0
6. Jordan Harbour	Mid-season	3.0	—	—
7. Jordan Harbour	Mid-season	5.4	—	—
8. Jordan	Mid-season	0.9	—	—
<i>Three DDT sprays</i>				
1. Vineland (Experimental)	Elberta	—	1.4	0
9. Vineland	Mid-season	17.2	—	—
10. Vineland	Elberta	30.5	—	—
11. Vineland Station	Mid-season	3.7	—	—
12. Vineland Station	Mid-season	1.4	—	—
13. Vineland Station	Mid-season	0.7	—	—
	Elberta	11.1	—	—
14. Jordan Harbour	Elberta	—	1.5	0.6

Table 7 Cont'd.

Orchard and locality	Variety	Percentage total fruit injury		
		1948	1949	1950
15. Jordan	Mid-season	13.0	—	—
16. Jordan	Elberta	—	8.5	0.7
<i>Checks — No DDT applied</i>				
17. Jordan	Mid-season	31.0	—	—
	Elberta	24.0	—	—
18. Jordan	Mid-season	11.6	—	—
19. Vineland Station	Elberta	67.5	—	—

In  $\frac{3}{4}$ -acre plots of Elberta at Leamington in 1950, the standard three-spray schedule was compared with one having three additional sprays for the first generation. Fruit injury at harvest was 0.1 per cent for the three-spray program, 0.0 per cent for six sprays, and 7.4 per cent in an unsprayed check.

In such low infestations as those in the experimental orchards in 1949 and 1950, both schedules produced such good control that the differences are of very doubtful significance. In 1948, however, in orchards where the infestations and the efficiency of spraying were comparable, those growers who used the longer schedule obtained somewhat better control than those who applied only three sprays. Whether the additional control given by the first-generation sprays compensated for their cost is a doubtful point to be considered later.

#### DEVELOPMENT OF A BASIC DDT SCHEDULE

From the experimental data obtained from 1946 through 1950, and from growers' experience, it appears that increasing the number of DDT applications, up to a maximum of six or seven, increases the degree of oriental fruit moth control. However, each additional application above one tends to be of diminishing value, so that at some point the gain in freedom from injury will not equal the cost of the extra sprays. The number of sprays giving the most economical control will vary with the intensity of infestation, the value of the crop, and the cost of labour and materials.

The degree of fruit infestation cannot be predicted. Attempts to forecast the infestation, on the basis of weather conditions, the amount of twig injury by first-generation larvae, and the degree of parasitism have been made over many years; but they have failed to give warning of severe fruit injury in time to allow for preventive measures. It is therefore necessary to use regularly a schedule that will give good control of the heavier infestations even if it is unnecessarily lengthy for average years. Most growers would insist on using the fuller schedule even if it could be proved that a shorter one might be more economical over a period of years.

For the third generation, only one spray is required; but this is the most important application on mid-season and late varieties because it controls 'invisible' injury. Unfortunately this is the application leaving the greatest amount of residue; in the spray recommendations for 1951 the amount of 50 per cent DDT has been reduced to 1 lb. and the interval between spraying and harvest set at four weeks.

Two applications of 50 per cent DDT at 2 lb. against the second generation must be used as insurance, although in some lightly infested orchards they might not be economically justified. Three sprays are not recommended for this generation for they give little, if any, better control than two.



To estimate the value of first-generation sprays, chief reliance must be placed on growers' results, as already explained. These generally showed less injury where the first-generation sprays were used. However, even in 1948 most growers who used only second- and third-generation sprays obtained satisfactory control when these were thoroughly applied.

The early applications are likely to cause greater disturbance of biological control factors. Aside from possible injury to the parasites of the oriental fruit moth, infestations of the European red mite, *Metatetranychus ulmi* (Koch), have tended to appear earlier in the season and have been more severe in orchards where first-generation sprays were used.

Though spraying for the first generation cannot be recommended as a general practice in Ontario because it is not economically sound, it may have a place under exceptional conditions. In some 'problem' orchards, particularly near canning factories, severe injury may recur nearly every year; here a full program for all three broods is justified.

A basic schedule comprising two DDT sprays for the second brood and one for the third has been recommended in 1949, 1950, and 1951, and unless some unusual circumstance intervenes will probably be advised for some time to come. The timing of the treatments is given in Table I, schedule D. These sprays are applied only in bearing orchards.

The use of DDT in peach orchards, even when limited to three applications, has had some objectionable but unavoidable effects. At least one and usually two or three acaricidal treatments have been needed each year to control the European red mite, and some other pests have shown signs of increase where DDT has been applied. However, the recommended schedule has had much less effect on *Macrocentrus ancylivorus* Rohw, the most important parasite of the fruit moth, than was feared, possibly because most young orchards are not sprayed.

#### OTHER INSECTICIDES FOR THE CONTROL OF FRUIT INJURY

##### PARATHION

*Experimental Results.*—In 1948 parathion was compared with DDT in a schedule of one second- and two third-generation sprays. The results are given in Table VIII. This schedule, as shown previously, was poorly timed, but it was evident that parathion failed to give protection from third-generation attack. Control of the second brood was at least as good as that given by DDT.

Table VIII

#### EFFECTIVENESS OF SPRAYS OF DDT AND PARATHION AGAINST SECOND AND THIRD GENERATIONS OF THE ORIENTAL FRUIT MOTH IN ORCHARDS 8 AND 19, NIAGARA PENINSULA, 1948-1950

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	'Invisible'	Total	
Orchard 8 — Variety Elberta — 1948										
A	2	—	July 15	2nd						
	2	—	Aug. 2 & 26	3rd	992	11.2	1.4	3.6	16.2	74.0
C	—	3 <sup>1</sup> / <sub>8</sub> ( <sup>1</sup> )	July 15	2nd						
	—	1 <sup>2</sup> / <sub>8</sub>	Aug. 2 & 26	3rd	902	7.5	0.9	20.2	28.6	54.1
D	—	1 <sup>2</sup> / <sub>8</sub>	Aug. 2 & 26	3rd	795	36.2	3.6	27.2	67.0	—
B										
Check	—	—	—	—	968	38.5	2.1	21.6	62.2	—

(<sup>1</sup>)Proportional amounts of 25 per cent parathion were used in 1948.

Table VIII cont'd.

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	'Invisible'	Total	
Orchard 8 — Varieties Vedette and Veteran — 1949 (average for duplicate plots)										
A1 & A2	2	—	June 27 & July 13	2nd						
	1½	—	July 27	3rd	3,439	3.0	0.2	0.5	3.8	72.4
F1 & F2	—	1	June 27 & July 13	2nd						
	—	1	July 27	3rd	3,159	2.0	1.0	3.1	6.2	55.1
E1 & E2	—	—	—	—	—	—	—	—	—	—
Check	—	—	—	—	3,147	5.5	3.6	4.7	13.8	—
Orchard 8 — Variety Elberta — 1949 (average for duplicate plots)										
A1 & A2	2	—	June 27 & July 13	2nd						
	1½	—	Aug. 15	3rd	2,802	2.6	0.4	1.7	4.7	61.2
F1 & F2	—	1	June 27 & July 13	2nd						
	—	1	Aug. 15	3rd	3,077	2.7	0.7	2.3	5.8	52.1
E1 & E2	—	—	—	—	—	—	—	—	—	—
Check	—	—	—	—	2,671	5.3	1.3	5.4	12.1	—
Orchard 10 — Variety Elberta — 1949										
A	—	1½	June 27 & Aug. 16	3rd	3,249	1.5	0.02	0.0	1.5	77.6
B	2	¾	June 27 & July 14	2nd						
	1½	—	Aug. 16	3rd	3,487	0.5	0.05	0.0	0.5	92.6
C	2	—	June 27 & July 14	2nd						
	1½	—	Aug. 16	3rd	2,644	0.9	0.03	0.5	1.4	79.2
D	—	—	—	—	—	—	—	—	—	—
Check	—	—	—	—	3,168	4.2	0.7	1.8	6.7	—
Orchard 10 — Variety Elberta — 1950										
D	—	—	—	—	—	—	—	—	—	—
A	—	1½	July 13 & 24	2nd						
	—	1	Aug. 24	3rd	3,052	0.2	0.0	0.0	0.2	98.2
B	2	¾	July 13 & 24	2nd						
	1	—	Aug. 24	3rd	2,433	0.04	0.0	0.4	0.4	92.7
C	2	—	July 13 & 24	2nd						
	1	—	Aug. 24	3rd	2,834	0.2	0.04	0.4	0.6	94.5
Check	—	—	—	—	2,256	2.4	1.6	6.9	10.8	—

In 1949 and 1950 parathion was used in two second-generation and one third-generation applications. In orchard 8 (Table VIII), the results in 1949 were similar to those of 1948; control of the second brood was comparable to that given by DDT, but third-generation injury was higher in the parathion plots. However, in orchard 10 in both 1949 and 1950, parathion was equally as effective as DDT against both generations.

Table IX gives a summary of the control of third-generation injury ('new' plus 'invisible') by parathion and by DDT. It is difficult to account for the variations in the effectiveness of

parathion, but the intensity of the infestation may be partly responsible. In any case it is evident that this insecticide will not give dependable control of the third generation. Even if it were effective, the use of parathion against this generation would be restricted because of the residue hazard.

Table IX

REDUCTION IN FRUIT INJURY FROM THIRD-GENERATION LARVAE  
OF THE ORIENTAL FRUIT MOTH BY PARATHION AND DDT.  
SUMMARY OF DATA IN TABLE VIII

Orchard	Varieties	Year	Percentage reduction in 'new' and 'invisible' injury	
			DDT	Parathion
8	Elberta	1948	79.0	10.9
8	"V" varieties	1949	91.5	50.5
8	Elberta	1949	69.7	56.0
10	Elberta	1949	80.0	99.3
10	Elberta	1950	99.4	100.0

Table X

EFFECTS OF PARATHION ADDED TO THE FIRST AND SECOND SPRAYS  
OF A THREE-SPRAY SCHEDULE OF DDT  
FOR THE CONTROL OF THE ORIENTAL FRUIT MOTH

Plots, varieties, and year					Percentage reduction in injury	
					DDT alone	DDT with parathion
A & B	— Orchard	8	— "V" varieties	1949	72.4	84.2
C & D	"	8	" "	1949	78.4	67.7
A & B	"	8	Elberta	1949	61.2	68.7
C & D	"	8	"	1949	95.1	78.5
B & C	"	10	"	1949	79.2	92.6
B & C	"	10	"	1950	94.5	92.7
Average					80.1	80.7

Parathion (15 per cent) at three-quarters of a pound was added to the second-generation moth sprays in two orchards in 1949 and 1950 for the control of the European red mite. The results, as given in Tables V and VIII and summarized in Table X, show that the addition of parathion did not produce any increase in control over that from DDT alone.

In a second experiment in 1950 in a young peach orchard just coming into bearing at Vineland Station, schedules of six sprays of parathion, DDT, and ethyl p-nitrophenyl thionobenzenephosphonate (EPN) were compared. The timing of the sprays was as follows: first generation — June 5, 12, and 22; second generation — July 13 and 26; and third generation — Aug. 25.

The results given in Table XI indicate that DDT was slightly better than parathion, although the difference may not be significant. EPN failed to give as good control, especially of the third generation, as the other materials. A further discussion of these sprays on twig-feeding larvae is given on page 65.



*The Place of Parathion in the Spray Schedule.*—Parathion has been shown to be as effective as DDT for the control of the second generation of the oriental fruit moth. It also affords good control of the European red mite and the cottony peach scale, *Pulvinaria occidentalis* Ckll. [= *P. amygdali* auct.], which are not suppressed by DDT, and probably of other pests against which it has not yet been thoroughly tested. Because of its wide range of usefulness, parathion (15 per cent) at 1 lb. has been recommended to growers in 1951 as an alternative to DDT in the two sprays against the second generation of the moth in orchards where the cottony peach scale has to be controlled. The only reason why it should not completely replace DDT in these sprays is the danger to human life. One of the greatest hazards in its use is in thinning peaches sprayed with it, as many growers do not complete thinning before the first of the second-generation sprays should be applied.

#### ETHYL P-NITROPHENYL THIONOBENZENE PHOSPHONATE (EPN-300)

An experiment in which six-spray schedules of EPN, parathion, and DDT were compared in 1950 has been described in the section on parathion. The results as given in Table XI show that EPN gave the poorest control of fruit infestation.

An experiment was conducted in small plots in the Science Service orchard at Harrow in 1950, comparing EPN and DDT in two second-generation sprays. One third-generation spray

Table XI

#### COMPARISON OF DDT, PARATHION, AND EPN AGAINST FRUIT-FEEDING LARVAE OF THE ORIENTAL FRUIT MOTH ON ELBERTA PEACHES, 1950

Plot	Material per 100 gal.	Total fruit	Percentage fruit injury				Percentage reduction in injury
			Old	New	'Invisible'	Total	
8	DDT 50%, 2 lb.*	645	0	0	0.5	0.5	94.5
7	Parathion 15%, 1 lb.	827	0.8	0	0.9	1.7	87.5
10	EPN 27%, $\frac{3}{4}$ lb.	1039	1.0	0.2	2.5	3.7	74.6
9	Unsprayed check	837	5.8	1.7	6.8	14.3	—

of DDT was used in each plot. This orchard was very heavily attacked by third-generation larvae, so that 'invisible' injury was very high on Elberta. The results are given in Table XII. In all cases the injury, largely caused by the third generation, was much higher in the EPN plots than in comparable DDT plots.

Table XII

#### COMPARATIVE CONTROL OF THE ORIENTAL FRUIT MOTH WITH EPN-DDT AND DDT SPRAY SCHEDULES; SCIENCE SERVICE ORCHARD, HARROW, ONT., 1950

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT	EPN				Old	New	'Invisible'	Total	
	50%	27%								
Variety Valiant										
1	—	1	July 11 & 21	2nd						
	1½	—	Aug. 4	3rd	936	0.6	0.1	1.6	2.3	78.1
2	2	—	July 11 & 21	2nd						
	1½	—	Aug. 4	3rd	876	0.9	0.0	0.0	0.9	91.4

\*Except in the last spray (Aug. 25) when 1½ lb. was used.

Table XII cont'd.

Plot	Pounds per 100 gal. DDT 50%	Parathion 27%	Spray dates	Larval generation	Total fruit	Old	Percentage fruit injury New	'Invisible'	Total	Percentage reduction in injury
3										
Check	—	—	—	—	1,060	3.9	2.8	3.8	10.5	—
1A	—	1	July 11 & 21	2nd						
	1½	—	Aug. 4	3rd	1,396	0.1	0.2	6.6	6.9	41.5
2A	2	—	July 11 & 21	2nd						
	1½	—	Aug. 4	3rd	836	0.2	0.2	1.7	2.1	82.2
3A										
Check	—	—	—	—	1,207	5.2	1.0	5.6	11.8	—
Average of EPN-DDT plots—						0.3	0.2	4.1	4.6	59.8
Average of DDT plots —						0.6	0.1	0.8	1.5	86.8
<i>Variety Elberta</i>										
1	—	1	July 11 & 21	2nd						
	1½	—	Aug. 22	3rd	1,444	1.4	1.4	8.3	11.1	52.8
2	2	—	July 11 & 21	2nd						
	1½	—	Aug. 22	3rd	990	0.9	0.3	0.0	1.2	95.0
3										
Check	—	—	—	—	887	4.5	2.3	16.7	23.5	—
1A	—	1	July 11 & 21	2nd						
	1½	—	Aug. 22	3rd	1,198	2.2	1.4	19.8	23.4	55.4
2A	2	—	July 11 & 21	2nd						
	1½	—	Aug. 22	3rd	1,590	1.6	1.0	9.3	11.9	77.3
3A										
Check	—	—	—	—	1,120	6.9	7.8	37.8	52.5	—
Average for EPN-DDT plots —						1.3	1.4	14.0	17.2	54.1
Average for DDT plots —						1.2	0.6	4.6	6.6	86.0

## RESIDUES OF DDT AND OF PARATHION ON THE FRUIT AT HARVEST

A sample of one 6-qt. basket of fruit was collected at random from each of a number of the experimental plots, usually at the time of the first picking. They were shipped by railway express to Kentville, N.S., or Ottawa, Ont., where analyses of residues were made through the co-operation of the Division of Chemistry, Science Service.

Samples were also collected in 1950, but the analyses have not been completed.

The residue values for 1946 to 1949 inclusive are given in Table XIII. The amounts varied greatly, owing to chances of sampling and to differences in the rates of weathering and in increase of surface area. The only conclusions that can be drawn are that increase in the number of applications is likely to leave greater residue, and that the last application usually leaves a relatively greater amount than the earlier ones.

The residues of DDT are high enough in a number of cases to cause concern, as they are much above any suggested tolerance. Unfortunately no residue values are yet available for the 1950 schedules, in which the amount of DDT in the last spray was reduced to one pound.

The parathion residues were still more variable, possibly because the amounts are so small. None of the schedules left residues that could be considered excessive.

Table XIII  
INSECTICIDE RESIDUES OF DDT AND PARATHION ON PEACHES  
AT HARVEST IN ONTARIO, 1946-1949  
VALUES IN BRACKETS FROM DUPLICATE PLOTS  
VARIETY ELBERTA UNLESS OTHERWISE INDICATED

Year	Locality	Days between sprays & harvest	DDT 50% or Parathion 15% lb. per 100 gal. per application	Residue p.p.m.
<i>DDT Residue</i>				
1946	Niagara Peninsula	43, 22	2, 2	7.7
	" "	45, 26	2, 2	6.6
1947	" "	28	2	12.3
	" "	46, 26	2, 2	8.5
1948	" "	27	2	12.6
	" "	33	2	6.4
	" "	47, 28	2, 2	15.3
	" "	49, 33	2, 2	10.0
	" "	67, 49, 33	2, 2, 2	10.8
1949	" "	62, 21	2, 1½	4.5
	" "	75, 58, 25	2, 2, 1½	9.1
	" "	75, 59, 26	2, 2, 1½	6.8, 3.1
	" "	75, 63, 54, 26	2, 2, 2, 1½	11.1, 8.8
(Vedette)	" "	57, 41, 27	2, 2, 1½	5.3
	Essex County	25	1½	2.6
	" "	63, 48, 25	2, 2, 1½	6.9
	" "	66, 51, 39, 28	2, 2, 1½, 1½	11.7
	" "	70, 59, 46, 28	2, 2, 2, 1½	14.2, 16.7
<i>Parathion Residue</i>				
1949	Niagara District	75, 58	¾, ¾	0.018
	" "	72, 59, 26	1, 1, 1	0.036
	" "	75, 58, 25	1½, 1½, 1	0.17
(Veteran)	" "	57, 41, 28	1, 1, 1	0.002, 0.028

#### CONTROL OF TWIG-INFESTING LARVAE

A two-acre peach orchard of several varieties, planted in 1947, was used to test the relative effectiveness of DDT and parathion against twig-infesting larvae of the first and second generations. In the spring of 1949 these trees varied from 4 to 6 ft. in height; they made exceptionally heavy growth throughout the summer, providing very favourable conditions for larval feeding.

The block was divided into five plots of 35 to 49 trees each, and sprayed six times, the sprays being timed according to the stage of growth on bearing trees and the development of the moth: May 9 (petal-fall stage), May 18 (shucks 50 per cent fallen), May 30 (shucks 95 per cent fallen), and June 7 for the first generation; and June 28 and July 12 for the second generation.

The treatments were as follows:

- Plot A: Parathion 15%, ¾ lb. per 100 gal.
- Plot B: Parathion 15%, 2 lb. per 100 gal.
- Plot C1: DDT 50%, 2 lb. per 100 gal.
- Plot C2: Duplicate of C1
- Plot D: Unsprayed check.



Table XIV

CONTROL OF TWIG-FEEDING LARVAE OF THE ORIENTAL FRUIT MOTH  
WITH PARATHION AND DDT ON THREE-YEAR-OLD PEACH TREES, 1949

Generation and period	Injured twigs per 4 trees per generation						Check No.	
	Plot A Parathion 15%, $\frac{3}{4}$ lb. No. % reduction in injury	Plot B Parathion 15%, 2 lb. No. % reduction in injury	Plot C 1 DDT 50%, 2 lb. No. % reduction in injury	Plot C 2 DDT 50%, 2 lb. No. % reduction in injury				
First; June 3 to 30	136	64.5	220	42.6	289	24.6	389 (increase)	383
Second; July 1 to 22	30	91.0	21	93.8	144	57.1	148	335
Third; July 23 to Aug. 27	108	33.4	118	27.2	179	(increase)	217 (increase)	162
Season	274	68.8	359	59.2	612	30.4	754 14.3	880

Results were taken by counting all injured twigs on four trees per plot twice weekly from June 3 to August 27. It should be kept in mind that increases in injury were caused not entirely by newly hatched larvae, but also in some cases by partially grown larvae leaving injured twigs and attacking fresh ones. As the season progressed it became increasingly difficult to make accurate counts owing to the great increase in growth.

The data from the bi-weekly counts have been grouped to cover the approximate feeding periods of the first three generations of larvae, and are presented in Table XIV.

Parathion (15 per cent) at either  $\frac{3}{4}$  or 2 lb. gave better control than DDT (50 per cent) at 2 lb. of both first- and second-generation twig-feeding larvae. Not a single injured twig was found on the record trees in either parathion plot until more than 10 days after the fourth spray against the first generation, whereas during the same period 26, 16, and 213 injured twigs were found in the two DDT plots and the check respectively. The superiority of parathion over DDT was greater for the control of the second generation than for the first.

Although appreciable twig injury was generally not apparent for 10 days after an application of parathion or DDT, the protection afforded by either material probably did not exceed five days when the twigs were growing rapidly; infested twigs cannot be detected until about four or five days after newly hatched larvae enter them.

The comparatively rapid build-up of injury in both the parathion and the DDT plots, starting about 10 days after the last spray of the season, was probably due to movement of moths from the check plot and to late-emerging moths from a small packing shed 100 yards from the orchard. Plot C2, in which DDT gave poorer control than in plot C1, was situated in the corner of the orchard nearest the packing shed.

In 1950 the same orchard was divided into four plots of approximately 50 trees each. They were sprayed five times with DDT, parathion, or EPN: June 5 (shuck-split stage), June 12-13 (shucks 50-75 per cent fallen), and June 22 for the first generation; and July 13 and 26 for the second generation. The petal-fall spray of the previous year was omitted, as it was too early to be of value. Treatments were as follows:—

Plot 7: Parathion 15%, 1 lb. per 100 gal.

Plot 8: DDT 50%, 2 lb. per 100 gal.

Plot 9: Check

Plot 10: EPN 27%,  $\frac{3}{4}$  lb. per 100 gal.

The results were taken as in 1949, by counting all injured twigs on four marked trees per plot at approximately 3- to 7-day intervals; the records in Table V have been grouped to show the number of twigs injured by each generation.

Table XV

CONTROL OF TWIG-FEEDING LARVAE OF THE ORIENTAL FRUIT MOTH  
WITH PARATHION, DDT, AND EPN ON FOUR-YEAR-OLD PEACH TREES, 1950

Generation and period	Injured twigs per 4 trees per generation							
	Plot 7—Parathion		Plot 8—DDT		Plot 10—EPN		Plot 9—Check	
	No.	% reduction in injury	No.	% reduction in injury	No.	% reduction in injury	No.	No.
First; June 12 to								
July 4	3	78.6	2	85.7	7	50.0	14	
Second; July 5 to								
Aug. 9	5	94.6	15	84.0	27	71.0	93	
Third; Aug. 9 to 31	0	100.0	14	78.2	19	73.0	64	
Season	8	95.4	31	81.9	53	69.1	171	

Again, parathion gave better control than DDT of twig-infesting larvae for the season as a whole. EPN was less effective than the other materials, but the comparison may have been biased because the EPN plot was situated on the side of the orchard nearest the packing shed and may have been exposed to a greater influx of moths.

#### DIRECT EFFECTS OF PARATHION AND DDT ON LARVAE IN TWIGS

On June 6, 1949, several unsprayed trees in the orchard used for the previous experiments were sprayed with parathion (15 per cent) at  $\frac{3}{4}$  lb. or 2 lb. Three days later samples of about 25 larvae were dissected from injured twigs on the trees receiving each dosage. Larval mortality on the trees sprayed with  $\frac{3}{4}$  lb. was 20.7 per cent, and on those receiving 2 lb., 80.7 per cent.

On June 28 a second series of trees was sprayed with either parathion (15 per cent) at  $\frac{3}{4}$  lb. or DDT (50 per cent) at 2 lb. Two days later samples of larvae were collected from each treatment and a check, the instars were separated by head-capsule measurements, and the mortality was determined. The data, summarized in Table XVI, showed that parathion had destroyed many of the larvae but that DDT had killed none. No data could be obtained on the mortality of the first instar because larvae of this stage do not produce visible injury and could not be located.

Table XVI  
MORTALITY OF ORIENTAL FRUIT MOTH LARVAE  
IN PEACH TWIGS SPRAYED ON JUNE 28;  
LARVAE EXAMINED ON JUNE 30, 1949

Treatment Amt. per 100 gal.	2nd instar		3rd instar		4th instar		Total	
	No. larvae	% dead	No. larvae	% dead	No. larvae	% dead	No. larvae	% dead
Parathion 15%, $\frac{3}{4}$ lb.	0	0	15	60.0	31	61.4	46	60.9
DDT 50%, 2 lb.	1	0	7	0	35	0	43	0
Check — unsprayed	1	0	9	0	34	2.9	44	2.3

#### USE OF INSECTICIDES AGAINST TWIG-INFESTING LARVAE

The general use of insecticides to prevent twig injury in young orchards has not been recommended in Ontario, because of the possible detrimental effects on parasites and also because the injury is seldom serious enough to justify the five or six applications needed to give good protection for the season. However, portions of some orchards near packing sheds or canning factories may be very badly infested, delaying the time of bearing and causing mis-shapen trees; in these situations spraying may be profitable.

#### CONCENTRATE MIST SPRAYING FOR ORIENTAL FRUIT MOTH CONTROL

During the summers of 1949 and 1950 a few experiments were conducted in two peach orchards, primarily on oriental fruit moth control, with concentrate mist spraying in comparison with conventional high-pressure spraying. The concentrate mist sprayer, manufactured in British Columbia, had a fixed fish-tail outlet and sprayed from one side only. The manufacturer's specifications were as follows:—

Weight empty: 1,600 lb.

Pump: 3 gal. per min. at 300 lb. per sq. in.

Turbine: axial flow, 14 in. diam.

Velocity at fish-tail: 90 m.p.h.

Air displacement: 8,000 cu. ft. per min.

Tank capacity: 100 imperial gal.



All spraying was done in the daytime. The wind velocity during most of the applications was 3 to 4 m.p.h.; occasionally it reached 6 m.p.h. and on one occasion 8.9 m.p.h. at one foot above the tops of the trees.

In 1949, a three-acre plot of mixed 'V' and Elberta peaches was sprayed with the concentrate mist sprayer and compared with conventionally sprayed plots that adjoined on each side.

The latter plots were sprayed from the ground at 400-lb. pressure. The standard schedule of two second-generation sprays containing 2 lb. of 50 per cent DDT, and one third-generation spray at 1½ lb. per 100 gal. was followed, parathion usually being added to one or two of the second-generation sprays for the control of the European red mite. Sulphur was also added to some applications for brown rot control. In 1949 approximately 3.75 gal. of spray were applied per tree per application. This amount was equivalent to 7.5 lb. of 50 per cent DDT per acre for each of the first two applications and 5.6 lb. for the third.

It was the intention to apply the same amount of DDT per acre by the concentrate machine, but owing to inexperience and an error in calculating the capacity of the tank on the conventional sprayer, approximately 39 per cent more was applied in the form of the 7½× concentrate than by the conventional sprayer, the amounts of 50 per cent DDT per acre in the concentrate averaging 12.2 lb. for the first applications and 9 lb. for the last. Because of variations in driving speed the actual amounts varied considerably in different parts of the orchard.

In 1950 the same plots and the same basic schedule were again used. The concentrates were applied more uniformly and accurately than in 1949, and the amounts of DDT applied by the two methods were more nearly comparable: slightly less material was purposely used in the concentrate applications. The rates are given in Table XVII.

Table XVII

RATES OF APPLICATION OF DDT  
BY CONCENTRATE AND CONVENTIONAL SPRAYERS, 1950

<i>Application</i>	<i>Concentration</i>	<i>DDT 50% lb. per 100 gal.</i>	<i>Gal. per tree</i>	<i>DDT 50% lb. per acre</i>
Conventional				
1st and 2nd sprays	1×	2.0	3.6	7.2
3rd spray	1×	1.5	4.0	6.0
Concentrate				
1st and 2nd sprays	3.3×	6.6	1.0	6.6
3rd spray	3.2×	4.8	1.0	4.8

The fruit injury at harvest is given in Table XVIII and summarized in Table XIX. The injury in the concentrate plots averaged slightly less than in those receiving conventional dilute sprays.

Table XVIII

COMPARISON OF CONCENTRATE MIST AND CONVENTIONAL  
DILUTE SPRAYS FOR ORIENTAL FRUIT MOTH CONTROL,  
ORCHARD 8, 1949 AND 1950

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	'Invisible'	Total	
Varieties Vedette and Veteran — 1949										
Conventional Sprayer										
B1+B2	2	¾	June 27 & July 13	2nd						
	1½	—	July 27	3rd	2,839	1.6	0.2	0.4	2.2	84.2
A1+A2	2	—	June 27 & July 13	2nd						
	1½	—	July 27	3rd	3,493	3.0	0.2	0.5	3.8	72.4
Concentrate Sprayer										
G	14½	—	June 27	2nd						
	14½	3⅞	July 13	2nd						
	11	—	July 27	3rd	2,847	3.0	0.3	0.5	3.8	72.4
H	14½	—	June 27 & July 13	2nd						
	11	—	July 27	3rd	2,790	1.5	0.3	0.8	2.6	81.2
E1+E2										
Checks	—	—	—	—	3,147	5.5	3.6	4.7	13.8	—
Variety Elberta — 1949										
Conventional Sprayer										
B1+B2	2	¾	June 27 & July 13	2nd	2,379	1.7	0.2	1.9	3.8	68.7
A1+A2	2	—	June 27 & July 13	2nd						
	1½	—	Aug. 15	3rd	2,802	2.6	0.4	1.7	4.7	61.2
Concentrate Sprayer										
G	14½	—	June 27	2nd						
	14½	3⅞	July 13	2nd						
	11	—	Aug. 15	3rd	2,710	1.9	0.2	0.5	2.7	77.7
H	14½	—	July 27 & July 13	2nd						
	11	—	Aug. 15	3rd	2,674	2.2	0.4	0.5	3.1	74.3
E1-E2										
Check	—	—	—	—	2,671	5.3	1.3	5.4	12.1	—
Varieties Vedette and Veteran — 1950										
Conventional Sprayer										
D1-D2	2	¾	July 11 & 21	2nd						
	1½	—	Aug. 7	3rd	3,951	0.4	0.02	0.7	1.2	91.8
C1-C2	2	—	July 11 & 21	2nd						
	1½	—	Aug. 7	3rd	5,472	0.6	0.01	0.9	1.6	89.1
Concentrate Sprayer										
B	6.7	2½	July 11 & 21	2nd						
	5	—	Aug. 7	3rd	2,471	0.9	0.1	0.0	1.0	93.2

Table XVIII cont'd.

Plot	Pounds per 100 gal.		Spray dates	Larval generation	Total fruit	Percentage fruit injury				Percentage reduction in injury
	DDT 50%	Parathion 15%				Old	New	Invisible	Total	
A2	6.7	—	July 11 & 21	2nd						
	5	—	Aug. 7	3rd	1,911	0.3	0.05	0.0	0.3	98.0
H1-H2										
Checks	—	—	—	—	4,295	4.5	0.6	9.5	14.6	—
<i>Variety Elberta — 1950</i>										
<i>Conventional Sprayer</i>										
D1	2	$\frac{3}{4}$	July 11 & 21	2nd						
	$1\frac{1}{2}$	—	Aug. 22	3rd	251	0.8	0.4	0.0	1.2	97.2
C1+C2	2	—	July 11 & 21	2nd						
	$1\frac{1}{2}$	—	Aug. 27	3rd	799	0.9	0.0	3.0	3.9	90.7
<i>Concentrate Sprayer</i>										
B	6.7	$2\frac{1}{2}$	July 11 & 21	2nd						
	5	—	Aug. 27	3rd	317	1.9	0.3	0.0	2.2	94.8
A2	6.7	—	July 11 & 21	2nd						
	5	—	Aug. 27	3rd	778	0.9	0.6	0.9	2.4	94.2
H1+H2										
Checks	—	—	—	—	941	17.9	6.1	17.4	41.4	—

Table XIX

SUMMARY OF RESULTS WITH CONCENTRATE MIST AND CONVENTIONAL SPRAYS  
IN CONTROLLING THE ORIENTAL FRUIT MOTH IN 1949 AND 1950

Variety and Year	Conventional		Concentrate	
	Average fruit injury Per cent	Reduction in injury Per cent	Average fruit injury Per cent	Reduction in injury Per cent
Vedette and Veteran — 1949	3.0	78.3	3.2	76.8
Elberta — 1949	4.2	64.9	3.4	76.0
Vedette and Veteran — 1950	1.4	90.4	0.7	95.6
Elberta — 1950	2.5	93.9	2.3	94.5
Average	2.8	81.9	2.4	85.7

Another orchard was also sprayed with the concentrate machine in 1949. Control of the oriental fruit moth was very good, although no conventionally sprayed plots were available for direct comparison.

Where either parathion or DN-III was added to the concentrate sprays, the infestations of the European red mite were held at a low level. Little information was obtained on brown rot control where sulphur was included, because of a low incidence of the disease in the experimental plots.



## SUMMARY

In Ontario, the most practical spray schedule for the protection of peach fruit against the oriental fruit moth was found to be one comprising two sprays of 50 per cent DDT at 2 lb. per 100 gal. for control of second-generation larvae and one of 1 lb. against the third generation. Fewer sprays did not give sufficient protection; additional sprays gave increased control but were not sufficiently better to compensate for their cost. Sprays against the first generation were justified only in exceptional circumstances. Parathion was as effective as DDT in second-generation sprays but was inferior for the third generation. Ethyl p-nitrophenyl thionobenzenephosphonate was least effective.

For the control of twig-feeding larvae the order of effectiveness was: parathion, DDT, and ethyl p-nitrophenyl thionobenzenephosphonate. Parathion killed many of the larvae within the twigs, whereas DDT did not.

For two seasons, concentrate mist sprays gave as good control of fruit injury as dilute sprays applied by conventional high-pressure sprayers.

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TIMBER TYPES IN RELATION TO  
INSECT OUTBREAKS IN THE CANADIAN  
ROCKY MOUNTAINS<sup>1</sup>

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## INTRODUCTION

The importance of the forests of the Canadian Rocky Mountains cannot be gauged by commercial timber values alone. Portions of this region aggregating 8,000 square miles in area have been organized into national parks. The remaining forested area, comprising 149,000 square miles, is owned mainly by the Province of Alberta. Although the recreational and the commercial timber values are of prime importance, the maintenance of proper watershed conditions on the eastern slope is even more vital.

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Some of the forests of this region are highly susceptible to outbreaks of destructive forest insects of several species. There is an apparent correlation between the number and severity of such outbreaks and the type of timber stand. In order to get some insight into the causes of these outbreaks, immediate control measures possible, and more nearly permanent remedies, it is necessary to know something about the history and characteristics of the timber types.

### CHARACTER OF THE TIMBER STANDS

There are six distinct timber types in the Canadian Rocky Mountains. They may be defined as follows:—

1. *Alpine fir type*.—Restricted stands of alpine fir, *Abies lasiocarpa* (Hook.) Nutt. on the upper slopes and in high alpine valleys, 6,000 to 7,000 feet in elevation, sometimes associated with whitebark pine, *Pinus albicaulis* Engelm., and alpine larch, *Larix lyallii* Parl. This is a climax type that has occupied these areas for a long period.

2. *Western White and Engelmann spruce type*.—Stands composed mainly of spruce, either *Picea engelmanni* Parry or *Picea glauca* (Moench) Voss var. *albertiana* (S. Brown) Sarg., with small percentages of alpine fir and lodgepole pine, *Pinus contorta* Dougl. var. *latifolia* Engelm. These are climax stands 300 to 500 years old, mainly in sub-alpine valleys.

3. *Lodgepole pine type*.—Extensive pure stands of young lodgepole pine or fully stocked stands of mature pine with an understory of spruce, associated in places with trembling aspen and Douglas fir. This is a fire succession type that has originated during the last 200 years. It is transitional and will eventually revert to the spruce type in most cases.

4. *Trembling aspen type*.—Pure stands of trembling aspen, *Populus tremuloides* Michx., not so extensive as type 3, often with an understory of young spruce. This also is a fire succession type and is often supplanted by spruce, for which it acts as a nurse crop.

5. *Douglas fir type*.—Relatively pure stands of Douglas fir, *Pseudotsuga taxifolia* (Poir.) Britton, associated with small amounts of lodgepole pine, spruce, and trembling aspen. This type is not widespread but is very distinct and attains its best development in the Porcupine Hills of south-central Alberta. This appears to be a climax type, for some of the trees are 500 years old, and the reproduction is composed mainly of Douglas fir.

6. *Black spruce type*.—Relatively pure stands of black spruce, *Picea mariana* (Mill.) B.S.P., associated on wetter sites with tamarack, *Larix laricina* (Du Roi) K. Koch., and on drier sites with white spruce, lodgepole pine, or jack pine, *Pinus banksiana* Lamb. This is a climax type of northern Alberta and the Northwest Territories.

### SUSCEPTIBILITY OF STANDS TO INSECT OUTBREAKS

All of the major outbreaks of forest insects in this region during the past 40 years have occurred in the transitional or fire-succession timber types. This may or may not be significant, for 40 years is a very short period in the life of a forest. Of greater significance is the fact that no destructive outbreaks have occurred in the climax types for 300 to 500 years; this suggests a balance of faunal populations in relation to environment. If fire can be kept out of the transitional stands, they will revert to climax types, in which a similar balance will probably be established. This will take a long time, and major outbreaks undoubtedly will occur meanwhile. Timber utilization can hasten the replacement of transitional species with climax species and will be an important factor in maintaining or destroying the resistance of present climax stands.

The estimate of the susceptibility of each timber type is based on the character and history of the stand and the incidence and destructiveness of past outbreaks.

The alpine-fir stands are subject to sporadic restricted attack by the western balsam bark beetle, *Dryocoetes confusus* Swaine. The trees killed are usually overmature, the effect being similar to that of a selection cut making room for more vigorous young trees. Utilization is not feasible because of inaccessibility, and the net result of the bark-beetle activity is actually beneficial under these conditions. Susceptibility to insect outbreaks may be classed as medium in this timber type.

The climax spruce stands have low susceptibility to insect outbreaks. No destructive infestations have occurred in these stands for hundreds of years. Injury from the two-year-cycle spruce budworm has occurred sporadically during the past 30 years at least, but there has been no serious tree mortality.

The main fire-succession type, lodgepole pine, is highly susceptible to destructive and extensive outbreaks of the mountain pine beetle, *Dendroctonus monticolae* Hopk., and the lodgepole needle miner, *Recurvaria milleri* Busck. An outbreak of *D. monticolae* in Kootenay National Park began in 1930 and in 12 years killed 85 to 90 per cent of the timber over an area of 250 square miles. The estimated loss was over 400,000,000 board feet (4). An outbreak of the same beetle that started near Banff in 1940 was controlled after treatment of 30,000 trees on 15,000 acres. An outbreak of the lodgepole needle miner that commenced in 1942 in Banff National Park is still in progress and now covers 450 square miles in four national parks.

Susceptibility of stands to outbreaks of the mountain pine beetle is influenced by available moisture; composition of the stand, whether pure or mixed; age; distribution of diameter classes and site quality.

Most of the outbreaks in Western Canada have started during prolonged drought periods when the vigour of all trees was reduced (4). Beal (1) also found a relationship between drought and outbreaks of the Black Hills beetle, *Dendroctonus ponderosae* Hopk. Craighead (2) stated, "Extensive outbreaks of the southern pine beetle and hickory bark beetle have always occurred in drought years."

It is noteworthy that all of the large outbreaks of the mountain pine beetle have started in fully stocked stands of mature lodgepole pine. It seems reasonable to suggest that the pine in mixed stands is less susceptible to attack.

Very few, if any, outbreaks of *D. monticolae* have started in stands under 80 years of age. The limitation of trunk area on small trees prevents a rapid build-up of the beetle population. Moreover, Hopping and Beal (4) found a direct relationship of diameter to incidence of attack under outbreak conditions. Practically no attack occurred on trees below five or six inches in diameter, and for every inch increase above this there was an increase of approximately five per cent in the proportion of trees attacked.

Site quality seems to be another factor influencing stand susceptibility. In ponderosa-pine stands, the poorer sites are associated with greater bark-beetle hazard (5), but apparently this is not the case with lodgepole pine. All of the outbreaks of the mountain pine beetle in the Rocky Mountains have started on the better sites.

Severity of attack by the lodgepole needle miner does not seem to be associated with size or age of the trees, or with site quality, but the younger, more vigorous trees are able to withstand the attack over longer periods than the older, slower-growing stock.

The aspen fire-succession type is also subject to extensive outbreaks, chiefly of defoliators. Several species of tent caterpillars, *Malacosoma* spp., periodically cause extensive defoliation. More restricted areas of aspen are defoliated by the American poplar beetle, *Phytodecta americana* Schaeff., and the large aspen tortrix, *Archips conflictana* Wlkr. The poplar borer *Saperda calcarata* Say, causes severe damage in some areas.



The black-spruce stands of northern Alberta are of a climax nature, and no serious insect outbreaks have occurred in these stands for a long period. This timber type may be placed in the low susceptibility class.

### CONTROL POSSIBILITIES

The data presented indicate that the main insect problems arise in extensive stands of lodgepole pine. A bark-beetle outbreak can be controlled by applied methods if discovered in the early stages. A 100 per cent cruise is necessary to locate all infested trees, and each one must be treated by cutting and burning, by burning the trunk as it stands, or by killing the bark-beetle broods with certain penetrating chemicals.

No effective applied control has been developed for the lodgepole needle miner. Since the larva spends nearly all its time within the mine, it is difficult to develop a spray with sufficient penetration to kill the miner and not injure the trees. Even if this could be done, aeroplane spraying of 450 square miles of timber would require an expenditure of at least one and a half million dollars on the basis of present material and labour costs. Most of the parasites would be killed and the needle miner population would probably increase again very rapidly. The spray operation would have to be repeated every few years until the factors favouring increase became inoperative.

Applied control for the mountain pine beetle and the lodgepole needle miner is only a palliative. As long as these pure stands of mature and overmature pine remain, outbreaks will recur whenever other factors are favourable. It appears that longer-lasting results will be obtained by a thorough investigation of forest management with a view to replacing the lodgepole-pine stands with a mixed type more nearly climax in nature and of greater tree vigour. More nearly permanent beneficial results in the control of this needle miner may also be obtained by intensive investigations of biological factors.

Detailed forest management plans for areas in the Rocky Mountains and particularly in national parks cannot be made until much more timber inventory work is completed. The most desirable type of mixed stand can be determined only by silvicultural research to establish soil characteristics on the various sites in the region, and the soil and climatic factors best suited to the various species. A fairly reliable guide should be the composition of the climax types that originally occupied the pine areas; some clues have been left to indicate the nature of these stands.

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## WARBLE FLY CONTROL IN ONTARIO

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During 1945 and 1946, considerable interest was aroused throughout the province in the control of warble flies in cattle by power spraying. By the spring of 1947 it was quite evident that extensive control programmes of power spraying would be carried on in various township areas.

Although it was known that satisfactory control was being secured in western Canada and the western United States, no experimental work with power spraying had been carried out in Ontario or in the northeastern States where conditions were comparable to those of this province. It was realized by various workers that we had no assurance that satisfactory control would be secured in Ontario through power spraying.

Early in 1947 a meeting was called in the office of the Livestock Commissioner in Toronto, and an Ontario Warble Fly Committee was established to investigate the whole field of warble fly control in the province. The membership of this committee is as follows: Mr. W. P. Watson and Mr. R. H. Graham of the Ontario Livestock Branch, Professor R. G. Knox of the Department of Animal Husbandry, Ontario Agricultural College, Professor A. W. Baker, Professor W. C. Allan and Mr. S. E. Dixon of the Department of Entomology and Zoology, Ontario Agricultural College, Dr. A. A. Kingscote and Dr. J. K. McGregor of the Department of Parasitology, Ontario Veterinary College and Mr. H. L. Seamans of the Division of Entomology, Dominion Department of Agriculture.

## PROGRAMME IN 1947-1948

It was agreed that the first work should be an attempt to determine the actual larval mortality where power spraying was being used. Since the Department of Agriculture had an arrangement to financially assist Goderich Township in Huron County in a power spraying programme this township was selected to check its efficiency.

Teams working under the direction of the committee were sent into the township when spraying was completed to examine herds from farms selected at random. All grubs which could be extracted were removed and the numbers of live and dead grubs determined. Following are the results of the survey.

171 animals were examined after the first spray and 1088 grubs were checked. These showed a mortality of 14.7%.

79 additional animals were examined after the second spray and 386 grubs were checked. These showed a mortality of 37.1%.

93 unsprayed animals were examined as a control against mortality determinations. No dead grubs were secured.

In order to have a check against different conditions a survey was made in Chinguacousy Township in Peel County, where a power spraying programme was under way. 70 animals were examined after the third spray and 256 grubs were checked. These showed a mortality of 47.9%.

Some experimental work was undertaken in 1947 but the programme got under way so late that only small groups of animals could be secured. Results were therefore not conclusive. However, animals treated by the hand-scrubbing method with derris gave 90% mortality, which was a further check against mortality determinations.

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Since workers in the United States and western Canada state that a kill of grubs of 80% or better is necessary to secure adequate control, it was obvious that no satisfactory control was being secured in the areas checked in 1947. It was therefore decided to carry out a control programme under strict supervision, where each animal would be thoroughly sprayed, insofar as possible under Ontario conditions. Since the agreement of the Department of Agriculture with Goderich Township was still in effect in 1948, this township was selected for the programme, and a member of the Livestock Branch was placed in charge to supervise the spraying. The programme was well organized and thoroughly supervised. 5380 cattle in the township received two sprays in the general supervised programme apart from experimental herds. The spray, consisting of  $7\frac{1}{2}$  lbs. of derris (5% rotenone) in 80 Imperial gallons of water, was applied at 400 lbs. pressure and at the rate of approximately 1 gallon per animal.

Four teams, of two men each, checked the results in a large number of animals in the general supervised area, in experimental herds, in untreated herds as controls and in herds in townships in Huron and Bruce counties where unsupervised power spraying programmes were under way. Herds were selected at random. 2032 animals were examined in all, and 11,104 grubs extracted and the mortality determined. Checks were made at periods of from 7 to 12 days after treatment. On the farms checked, all animals which had been sprayed were examined. It should be noted that conditions for spraying on many farms in Goderich Township were probably as difficult as are likely to be found on Ontario farms.

Following are the results obtained from herds examined after the second spray in the supervised township and in unsupervised townships:

<i>Township</i>	<i>Number of Animals</i>	<i>Number of Grubs</i>	<i>Mortality</i>
<i>Supervised</i>			
<i>29 Herds</i>			
Huron County:			
Goderich	643	2368	81.1%
<i>Unsupervised</i>			
<i>44 Herds</i>			
Huron County:			
East Wawanosh	101	442	56.8%
Morris	146	1030	38.8%
Turnbury	70	492	85.2%*
Bruce County:			
Bruce	93	721	55.7%
Brant	45	303	57.1%
Greenock	71	652	51.7%
Carrick	111	437	36.8%
Culross	135	700	50.6%
Lindsay	52	150	52 %
Eastnor	44	306	84.9%*

It should be stressed that the number of grubs listed, includes only the number extracted and checked. It does not represent the total grub population. It should be borne in mind also that mature animals, through an apparent acquired immunity, may carry no grubs. The average number of grubs per immature infested animal is therefore much higher than these figures indicate.

\*It will be noted that these two townships show a much higher mortality than in any other unsupervised township. In Turnbury Township spraying was done on contract by the operator who also held the contract for Goderich Township—the supervised area. In Eastnor Township spraying was also exceptionally thorough according to the report of the District Representative of the Department of Agriculture.



## EXPERIMENTAL CONTROL STUDIES

Experiments were conducted in 1948 using entire herds. These included hand spraying, hand dusting and power spraying. Power spraying involved the use of different types of nozzle discs, different pressures, angles, and quantities of spray material. These factors were also studied in various combinations. The results form the basis of the Warble Fly Committee's present recommendations for control in Ontario. A portable chute, constructed by the Department of Agricultural Engineering of the Ontario Agricultural College, was used experimentally on several farms to simulate control conditions in Western Canada and the Western United States. Effective results were secured but such difficulty was encountered in getting the animals into the chute that its use is considered impracticable under Ontario conditions. The space required would not justify the recording here of details of experimental results or much information on such points as control in tied and untied animals, infestation in rough- and smooth-coated animals, and mature and immature animals. These can be secured from the records of the experimental work or from the accompanying survey. Hand-treated herds showed a mortality of 98.5%. Untreated herds again showed practically no dead grubs.

## BIOLOGICAL STUDIES

Studies were conducted to determine the time of appearance of grubs in the backs of animals and certain other life history features. Animals in the College herds were fitted with canvas "girdles" to catch mature larvae as they emerged from the backs. 179 other cattle were examined at weekly intervals over the season to determine the times of appearance of larvae in the backs. The results of these observation determined the Committee's recommendations for the timing of treatments. It is interesting to note that the 11,104 grubs checked in the whole programme were almost entirely those of *Hypoderma bovis* (L), the species which gads cattle in Ontario.

Reports on the biological studies carried on by J. D. Gregson at the Dominion Kamloops Laboratory were received regularly. These were of much value to the committee in their final recommendations with regard to the control programme in Ontario.

## ROTENONE CONTENT OF DERRIS POWDER

During the spraying season analyses for rotenone content of the derris powder used in Goderich Township were made. Efforts were made to have analyses done by various laboratories in Canada, but of those approached only the Chemistry Department of the Ontario Agricultural College was prepared to undertake the work. One analysis was made by the Ontario Research Foundation late in the fall, but possibly due to the material having been kept so long, the result was so at variance with the others that it had to be disregarded. Analyses also were made by the Insecticide Division of the Bureau of Entomology and Plant Quarantine at Washington. We appreciate the readiness of officers of the Bureau not only to assist in analyses but also their interest in and advice with respect to the whole programme. The derris powder used in Goderich Township was supplied on a basis of 4.6% rotenone. Of eleven analyses made one gave a result of 4.94%; all others ranged from 3.5% to 3.9%. Fortunately commercial controls were secured in Goderich Township. Otherwise it would have been necessary to throw the whole programme out on the basis of rotenone content. Samples of derris powder used in Bruce County and supplied on a 5% basis, showed analyses of 4.8%, 3.9% and 4.0%.

## PROGRAMME IN 1949 AND 1950

## POPULATION STUDIES

Surveys of numbers of larvae in the backs of cattle begun in 1948 were continued in 1949 and 1950. Immature cattle in untreated herds showed an average grub population in the three years of 12.2, 12.0 and 12.0 respectively. These surveys are of great value in assessing the effectiveness of the control programme. For example, in Bruce County where the mortality

was low after treatment in 1948, as shown in the previous table, the average population in immature animals was reduced from 11 in 1948 to 9.5 in 1949. With thorough supervised treatment in 1949, the population was reduced to 2.95 average in immature animals in 1950.

### PRESENT EXTENT OF CONTROL PROGRAMME

On recommendation of the Warble Fly Committee a revised Warble Fly Act was passed in the spring of 1949 with regulations under the Act also recommended by the committee. Inspectors are appointed under the Act for each township, and these inspectors are required to attend a one-day school in their area for training. Each inspector now receives a copy of a manual issued for his guidance. A chief inspector is appointed by the Province. In 1950, 59 townships carried on a control programme under the Act. 545,302 individual treatments of cattle were given in these townships. It is expected that over 70 townships in the Province will be under the Act in 1951.

Insofar as is known this is the first large scale control programme on the continent being conducted under conditions similar to those of this Province—where cattle are treated either tied, in loose boxes, or in temporary corrals in the field.

In general results have been very satisfactory. In some townships the population has been so reduced that the Warble Fly Committee is faced with the necessity of urging the township council to continue the programme.

The establishment of a Warble Fly Committee for the Province has been of great help in bringing together the various interested agencies.

Payment by the Province of half of the cost of the insecticide and half of the salary and expenses of each inspector has been of great help in encouraging the development of the programme.

On the basis of research, experimentation, surveys, and field experience the Warble Fly Committee has recommended the following programme now in effect in Ontario.

### NUMBER AND TIME OF TREATMENTS

At least two treatments must be applied. Three are recommended. Where only two treatments are given, times for these are from the 1st to the 18th of April inclusive and the 1st to the 31st of May inclusive. Not less than three weeks and not more than four weeks should elapse between treatments. Where a third treatment is given it should be in the period from the 2nd to the 17th of June inclusive.

### POWER SPRAYING

#### *Mixture*

Derris or Cubé (5% rotenone) at the rate of  $7\frac{1}{2}$  lbs. to 80 Imperial gallons of water or its equivalent.

#### *Quantity per Animal*

The skin of animals must be thoroughly wetted. This will require approximately 1 gallon per animal, depending on size and the density of coat. The time necessary to spray this volume should be determined with the aid of a time check by spraying into a container.

#### *Pressure*

A pressure of approximately 400 lbs. should be used. Higher pressures are not recommended.

### *Angle and Cone*

Spraying should be done directly on the animal's back at an angle of between 45° and 90°. The nozzle of the gun must not be over a foot from the animal's skin. The size of the cone of spray striking the animal should not be over six inches.

### *Spray Gun or Rod*

A gun with a quick shut-off should be used. The gun or rod should be about forty-eight inches in length, with a bend in the rod, or the nozzle at an angle, to give the proper angle in spraying.

### *Size of Nozzle*

A single nozzle with a No. 5 disc (5/64" diameter) should be used. Discs must be changed as they become worn.

### *Areas of Animals to be Treated*

The spray should be applied over an area 1 foot wide on each side of the backbone. This would involve the movement of the gun back and forth at least twice along the animal's back. The operator should be at the rear of the animal.

### *Disinfecting Equipment*

Operators' boots and equipment should be disinfected before leaving each farm.

## HAND TREATMENT

Control by this method consists in scrubbing the backs of infested animals with a derris or cubé-water mixture. The wash can be applied either, (a) from a sprinkler-top container and worked well into the hair with a brush or (b) the brush can be dipped into a bucket of the mixture. In either case, care should be taken to thoroughly wet the skin and to loosen any scabs over the grub holes.

### *Mixture for Hand Treatment*

Derris or Cubé (5% rotenone)	— ½ pound
Neutral soap	— 2½ ounces
(Alkaline soaps must not be used.)	
(7 ounces wettable sulphur may be used in place of soap.)	
Water	— 1 gallon.

There are commercial preparations on the market for hand treatment. These are all registered under the Pest Control Products Act and should be effective when used as directed.

As a supplement to power spraying, it is desirable to hand treat cattle which have only received two sprays and which may show evidence of late grubs after the last spraying and before the cattle are finally turned out to grass. Examine young stock particularly.

## SUMMARY

Studies of warble fly control in Ontario over a four year period are reported. The organization of the present extensive programme in Ontario under the Warble Fly Control Act, as directed by the Ontario Warble Fly Committee, is reported. Details of the present control measures are given.



## CHEMICAL CONTROL OF THE OYSTERSHELL SCALE IN THE GEORGIAN BAY AREA OF ONTARIO<sup>1</sup>

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In the apple-producing areas near Georgian Bay, Ontario, the oystershell scale, *Lepidosaphes ulmi* (L.), increased greatly in numbers during the early 'forties. By 1946 it was attacking apple trees in such numbers that limbs and even whole trees were killed, the varieties Baldwin and Northern Spy suffering to the greatest extent. The development of resistance to formerly effective control measures, and the effects of new spray materials and subzero temperatures on the parasites and predators of the scale, are possible factors responsible for the build-up in scale population. However, too little is known about the status of the natural enemies of the scale in Ontario and about the influence of spray treatments on them to permit any definite conclusion on the causes of the outbreak.

This paper covers the data obtained during chemical control studies carried on in six orchards near Thornbury from 1947 to 1949 inclusive. The individual plots contained 24 or more trees and in most cases were duplicated. Northern Spy and McIntosh were the principal varieties.

### MATERIALS

Some of the older and a number of the newer insecticides were tested in either dormant or summer applications, sometimes in combination with an acaricide. In the dormant treatments three types of oil were compared: 'regular' (low-paraffinic) tank-mixed, 'regular' emulsible, and 'superior' (high paraffinic) tank-mixed. Three dinitro materials, Elgetol, Krenite, and DN-289, were also used at the dormant stage. The summer treatments included summer oil (with and without nicotine), parathion, and DDT alone and in combination with the acaricides HETP, ammonia-DNOCHP, and mono-DNOCHP.

The dormant tank-mixed oils were emulsified with 4 oz. of 50 per cent blood albumen per 100 gal. of spray, irrespective of the concentration of oil. The summer oil was emulsified with 3 oz. of calcium caseinate per gallon of oil.

Specifications and sources of the materials were as follows:—

*Enarco Dormant Oil*.—"Regular" type. Viscosity Say. 170. Canadian Oil Company.

*Imperial Forum 46 Oil*.—"Regular" type. Viscosity Say. 228; viscosity index 77; gravity A.P.I. 26.3; pour point  $-30^{\circ}$  F.; flash point  $410^{\circ}$  F. Imperial Oil Company of Canada.

*Shell Neutrol Emulsible Oil*.—"Regular" type. Mineral oil 98.6%; viscosity Say. 200-210; gravity A.P.I. 24. Shell Oil Company of Canada.

*Superior Dormant Oil*.—"Superior" type. Viscosity Say. 90-120; viscosity index (kinematic) 110 minimum; gravity A.P.I. 32; pour point no greater than  $-30^{\circ}$  F.; homogeneity — a distillate with relatively narrow range in boiling point. Canadian Oil Company.

*Imperial X Oil 19-47*.—"Superior" type. Viscosity Say. 113; viscosity index 98; gravity A.P.I. 32; pour point  $-10^{\circ}$  F.; flash point  $390^{\circ}$  F. Imperial Oil Company of Canada.

*Marcol HX Oil*.—Viscosity Say. 75-85; unsulphonated residue 96%. Imperial Oil Company of Canada.

<sup>1</sup>Contribution No. 2756, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Officer-in Charge.

*Elgetol*.—Sodium dinitro-o-cresylate 19.95%; actual dinitro-o-cresol 17.6% (=26.7 oz. per can of 1 U.S. gal.). Standard Agricultural Chemicals, Inc.

*Krenite*.—Sodium dinitro-o-cresylate 25%; actual dinitro-o-cresol 22.5% (=34.2 oz. per can of 1 U.S. gal.). Canadian Industries Limited.

*DN-289*.—Triethanolamine salt of dinitro-secondary-butylphenol. Dow Chemical Company.

*DDT*.—50% wettable powder. Geigy Company Inc. (1947); Green Cross Insecticides Ltd. (1948 and 1949).

*Parathion*.—25% wettable powder, Dow Chemical Company. 15% wettable powder, American Cyanamid Company.

*HETP*.—Hexaethyl tetraphosphate. Niagara Brand Spray Company.

*Ammonia-DNOCHP*.—A tank-mixed preparation containing 2 fl. oz. of aqua ammonia and 5 oz. of finely ground dinitro-o-cyclohexylphenol per 100 gal. of spray. DNOCHP from Dow Chemical Company.

*Mono-DNOCHP*.—Prepared in the same manner as ammonia-DNOCHP but with monoethanolamine instead of ammonia.

*Nicotine sulphate*.—Black Leaf 40. 40% nicotine. Tobacco Byproducts & Chemical Corp.

#### TIME AND METHOD OF APPLICATION

The dormant applications, designed to destroy the overwintering eggs, were made in the spring while the buds were still dormant or only slightly swollen and at temperatures from 40 to 55° F. The summer applications, to kill the newly hatched 'crawlers', were made at petal-fall ('calyx' spray) and in a few cases 12 days later. The weather was moderately warm, and about 50 per cent of the scale eggs had hatched at petal-fall.

Treatment of the test plots differed from that of the checks, which received the standard bordeaux mixture-sulphur-arsenic schedule, in that the dormant materials were applied prior to the regular schedule, the special materials used in the summer were added to one or two of the standard applications at the times stated, and ferbam was substituted for sulphur on plots treated with summer oil.

Several conventional sprayers were used at different times and in different orchards. Each was equipped with an 8-nozzle broom, operated from the top of the tank, and a single gun on a ground line. The machines were operated at 425 to 600 pounds air pressure. In some applications each tree was completed at one operation; in others the trees were sprayed from two opposite sides, depending on wind and ground conditions.

#### RESULTS OF TREATMENTS

The treated trees were examined closely for bud or foliage injury, but no apparent detrimental effects were observed from any of the treatments. The efficiency of the various materials against the oystershell scale was determined by observing their effect upon eggs and crawlers and by late summer counts of young scales established on the wood of 100 terminal twigs of the current season's growth, and on the total fruits from one tree in each plot. The degree of control was calculated by Abbott's formula from the differences in scale counts between the treated plots and checks. Notes were also taken on the influence of the materials upon the European red mite, *Metatetranychus ulmi* (Koch); the white apple leafhopper, *Typhlocyba pomaria* McA.; and the codling moth, *Carpocapsa pomonella* (L.). No other insects were present in significant numbers. The results are summarized in Table I.

Table I

EFFECTIVENESS AND COSTS OF MATERIALS TESTED  
FOR CONTROL OF THE OYSTERSHELL SCALE,  
GEORGIAN BAY, ONT., AREA,  
1947-1949.

Material	Amt. per 100 gal.	No. of plots	Average, control % <sup>1</sup>	Cost per 100 gal. of spray
<i>Dormant treatments</i>				\$
Elgetol .....	1¼ can = approx. 1 gal.	4	99.7	3.80
Imperial Forum 46 oil.....	3 gal.	2	99.3	3.80
Krenite .....	1¼ can = approx. 1 gal.	2	99.3	3.80
DN-289 .....	3 qt.	2	63.0	3.75
Enarco dormant oil				
('regular' tank-mix) .....	5 gal.	2	98.0	1.70
Imperial Forum 46 oil				
('regular' tank-mix) .....	5 gal.	2	98.0	1.70
	4 gal.	2	80.0	1.40
	3 gal.	1	62.0	1.10
Shell Neutrol emulsible oil				
('regular' emulsible) .....	5 gal.	3	97.8	2.00
Superior dormant oil				
('superior' tank-mix) .....	4 gal.	2	96.1	1.75
Imperial X oil 19-47				
('superior' tank-mix) .....	4 gal.	2	78.9	1.75
	3 gal.	1	53.0	1.35
<i>Summer treatments (petal-fall unless otherwise stated)</i>				
DDT, 50% .....	2 lb.	2	96.8	.70
DDT, 50% .....	2 lb.			
Ammonia-DNOCHP .....	5 oz.	1	99.9	2.85
DDT, 50% .....	2 lb.			
HETP .....	½ pt.	1	99.9	2.85
DDT, 50% .....	2 lb.	1		
Mono-DNOCHP .....	5 oz.			
(a) Petal-fall .....		2	98.3	2.85
(b) Petal-fall and 12 days later		2	99.5	2.85
Parathion, 25% .....	2 lb.	2	99.7	1.41
Parathion, 15% .....	1 lb.			
(a) Petal-fall .....		2	93.8	.85
(b) 12 days later .....		2	53.0	.85
Marcol HX oil .....	1 gal.	3	93.8	1.70
Marcol HX oil .....	1 gal.			
Nicotine sulphate .....	1 pt.	1	96.3	4.15

*Dinitro Compounds.*—The dinitro pastes (Elgetol and Krenite) at 1 can (= 1 U.S. gal.) or 1¼ cans per 100 gal. of spray acted as very efficient ovicides and gave controls of 99 per cent or more. DN-289 at .75 per cent was relatively ineffective, giving about 62 per cent control. The addition of 3 per cent dormant oil emulsion to an Elgetol spray did not increase its effectiveness.

<sup>1</sup> On basis of Abbott's formula.



*Dormant and Summer Oils.*—Five per cent concentrations of the 'regular' dormant oils, either tank-mixed or emulsible, gave 98 per cent control, but 4 and 3 per cent emulsions of the tank-mixed oil gave only 80 and 62 per cent control respectively, which is not sufficient for commercial control. The so-called superior oils at 4 per cent were similar in cost to the 'regular' oils at 5 per cent but were somewhat less effective and at 3 per cent they were entirely inadequate.

All the dormant oils had low ovicidal value, their principal action being a high residual toxicity to the crawlers.

Summer oil (Marcol HX) at 1 per cent in the petal-fall spray gave 88 and 94 per cent control; the addition of nicotine sulphate, 1 pt. to 100 gal., raised this figure to 96 per cent but more than doubled the cost.

*DDT.*—An application of 50 per cent wettable DDT, 2 lb. of powder per 100 gal., at petal-fall (variety Northern Spy) was nearly 97 per cent effective in destroying the crawlers. The addition of an acaricide such as HETP, ammonia-DNOCHP, or mono-DNOCHP to the DDT spray gave controls of 98 to 99.9 per cent. Two applications (at petal-fall and 12 days later) of the last mixture produced no appreciable increase in scale mortality.

*Parathion.*—In 1948 parathion at 2 lb. of 25 per cent wettable powder in 100 gal. of the petal-fall spray gave 99.7 per cent control. In 1949, a 15 per cent wettable powder at 1 lb. per 100 gal. at petal-fall gave 93.8 per cent control but when applied 12 days later gave only 53 per cent.

#### EFFECTS OF TREATMENTS ON OTHER PESTS

Over the period of investigation the European red mite was the most important pest other than the oystershell scale. In 1947 the infestation developed to serious proportions in the check and dinitro-treated plots and caused conspicuous injury to the foliage by late July and August. In the plots that received either oils or acaricides the mite was held down to low levels, and where build-up did occur it came so late that no appreciable harm was done. The ratio of mites on August 22 was estimated at 10 in the check and dinitro plots to one in the oil- and acaricide-treated plots. An examination in October indicated a similar relationship in the numbers of winter eggs on the twigs and fruit.

In 1948 and 1949 this mite increased to large numbers and caused moderate to severe injury in some adjacent orchards but did not cause conspicuous injury in any of the experimental plots. There were, however, some distinct differences in mite populations from plot to plot, emphasized particularly in the numbers of winter eggs on the wood and fruit at the end of each season. Eggs were particularly numerous in plots that received DDT, light to moderate in numbers in the dinitro plots, and almost absent in plots that received dormant oils and parathion.

The white apple leafhopper occurred in outbreak form in the Georgian Bay area in 1948. In that season plots sprayed with DDT or with parathion at petal-fall were almost free of the insect whereas the plots treated with dormant oil, summer oil, or dinitro sprays were infested to such an extent that marked foliage injury occurred.

Treatments given either as dormant or as petal-fall applications did not reduce codling moth injury; on the contrary, these plots showed somewhat higher amounts of injury, ranging from 4 to 9.7 per cent as against 3.5 per cent in the check. The latter received only the standard fungicide plus arenic schedules. The injury in plots treated with DDT and an acaricide in the first cover (12-day) application compared closely with that in the check.

## DISCUSSION

Various materials will give good control of the oystershell scale. In choosing a treatment, both the cost and the effect on other pests must be considered.

Table 1 shows the approximate costs of the various materials used for each 100 gallons of dilute spray. The dormant treatments must be considered as extra sprays and therefore the cost of application must be added to the cost of the materials, whereas in the summer treatments the materials were added to one of the regular sprays at no additional cost for application. If oystershell scale control is the only consideration, it can obviously be accomplished readily and more cheaply with summer treatments.

The final choice of a treatment will depend largely on what other insects or mites are present. If the eye-spotted bud moth, *Spilonota ocellana* (D. & S.); the cigar casebearer, *Coleophora occidentalis* Zell.; or the rosy apple aphid, *Anuraphis roseus* Baker, is present in trouble some numbers a dinitro spray is preferable, as it will control these pests as well as the scale. One must keep in mind, however, that the use of a dinitro spray may lead to a mite problem and the need for an acaricide later in the season. The dinitros are the most expensive of the materials listed and acaricides, too, are expensive. Also, the dinitros will not control the fruit tree leaf roller, *Archips argyrospila* (Wlkr.).

Dormant oils are almost as effective as the dinitros against the oystershell scale. They will also control the fruit tree leaf roller and the San Jose scale, *Aspidiotus perniciosus* Comst., and will reduce the mite hazard very appreciably. They cost only about half as much as dinitro sprays, but they do not control the bud moth, the white apple leafhopper, the rosy apple aphid or the cigar casebearer.

Parathion in the petal-fall application is effective against the oystershell scale, the European red mite, and the white apple leafhopper. Its cost is comparatively low and it is added to a regular application. There are some hazards in its use.

DDT is highly effective against both the scale and the white apple leafhopper at low cost, but it favours the build-up of the European red mite and so may necessitate the use of an acaricide later in the season.

## SUMMARY

In experiments carried on in the Georgian Bay area of Ontario from 1947 to 1949 for the control of the oystershell scale, dormant treatments of either sodium dinitrocresylate or 5 per cent oil emulsions were very effective. At concentrations equivalent in cost, 'superior' (high paraffinic) oils were not more effective than 'regular' (low paraffinic) oils. Tank-mixed and emulsible oils were equally efficient. Dinitro-secondary-butylphenol was ineffective. Petal-fall applications of either DDT or parathion gave good control.

The dormant oils helped to control the European red mite, whereas the dinitro materials promoted mite injury. DDT favoured mite increase to an even greater extent but controlled the white apple leaf hopper. Parathion simultaneously controlled the oystershell scale, the European red mite, and the white apple leafhopper. The choice of a treatment for scale control depends on the cost and on the presence of other pests.

PRELIMINARY TESTS OF A SYSTEMIC  
INSECTICIDE FOR THE CONTROL OF APHIDS ON POTATOES<sup>1</sup>R. A. KELLEY<sup>2</sup>*Field Crop Insects Laboratory  
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Bennett (1949) defined a systemic insecticide as "a chemical substance which is absorbed by the plant and transferred to all parts of it, rendering it insecticidal". If a suitable systemic insecticide is developed, it should prove very valuable to potato growers. The ideal systemic insecticide is one that would produce, as the result of a single spray application, an insecticidal effect in the plant throughout the growing season. Such an insecticide, however, must not be stored in the tubers.

Martin (1950) reviewed the history of systemic insecticides and the factors affecting their practical use. Most research has been carried out by Ripper and others (1949, 1950) using the systemic insecticide schradan, bis (bis dimethylamino phosphonous) anhydride. These workers found that predacious insects, such as adult coccinellids and larvae of syrphids and parasitic Hymenoptera of the genus *Aphidius*, were not killed, whereas the aphids upon which they were feeding were killed by ingestion of the systemic insecticide. Thus, part of the usefulness of schradan lies in its apparent action as a selective insecticide.

Another systemic insecticide, Systox, diethyl ethylmercaptoethyl thiophosphate, has been produced recently by Geary Chemicals, New York, but little is known to date about its entomological, plant physiological, and toxicological properties.

## METHODS

The experimental area was planted on June 23 at Woodstock, N.B. The design was a randomized block of four treatments replicated twice. Each plot contained two rows of Katahdin potatoes, each row being 25 feet long. The plots were segregated from each other by barriers of oats nine feet wide. The treatments were as follows:—

A. Machine-made drills were sprayed with two pounds of Systox per 100 imperial gallons of water at the rate of 125 gallons per acre immediately before planting.

B. The seed pieces were dipped in a solution of two pounds of Systox per 100 imperial gallons of water immediately before planting.

C. The plants were sprayed with two pounds of Systox per 100 imperial gallons of water at the rate of 125 gallons per acre on July 13, one week after emergence.

D. On the checks no insecticide was used.

Weekly aphid counts were made on all the plots from July 18 to the end of August. The aphids were counted on a top, a middle, and a bottom leaf from each of five plants selected at random throughout each plot. Counts were expressed as aphids per 30 leaves. Aphids were identified as follows: the green peach aphid, *Myzus persicae* (Sulz.); the potato aphid, *Macrosiphum solanifolii* (Ashm.); the buckthorn aphid, *Aphis abbreviata* Patch.

The plants were top-killed on September 11 with a spray consisting of two gallons of Dowspray 66 Improved plus two pounds of aluminum sulphate per 100 imperial gallons of water, applied at the rate of 120 gallons per acre. The potatoes were harvested on September 15. Because of the lack of a fungicide application during the season, the plants were severely infected with late blight, *Phytophthora infestans* (Mont.) de Bary, which reduced the yield of disease-free tubers about 50 per cent.

Twenty-five tubers from each plot were analysed by the Geary Chemical Company by a bio-assay method.

<sup>1</sup>Contribution on No. 2815, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Technical Officer.



Table I

Weekly counts of three species of aphids on 30 leaves (three whole leaves per plant) of Katahdin potatoes after one application of each of three treatments with Systox, Woodstock, N. B., 1950.

Date	Myzus persicae Treatment*				Macrosiphum solanifolii Treatment				Aphis abbreviata Treatment				Total of Three Species Treatment			
	A	B	C	Check	A	B	C	Check	A	B	C	Check	A	B	C	Check
July 18	0	1	0	1	0	0	0	4	0	0	0	0	0	1	0	5
July 24	0	1	0	1	3	11	10	22	0	1	0	16	3	13	10	39
August 1	0	0	2	1	5	126	97	14	0	2	0	4	5	128	99	19
August 9	9	12	5	16	63	193	112	191	0	0	2	12	72	205	119	219
August 16	17	64	36	34	146	327	313	352	0	2	0	0	163	393	349	386
August 23	4	23	7	22	112	200	97	214	0	2	0	1	116	225	104	237
August 31	0	0	0	1	5	3	3	6	0	0	0	1	5	3	3	8

\* See text.

## RESULTS AND DISCUSSION

The weekly aphid counts are presented in Table I.

The most effective treatment for the three species of aphids was spraying the drills immediately before planting (treatment A). In all plots this appears to have reduced the number of aphids throughout the season. Table II shows that treatment A gave the only consistent control. The percentage reduction in aphid population effected by treatment A gradually decreased throughout the season, but by August 23 there was still a 51 per cent reduction.

Table II

Percentage reduction of aphids on potatoes after one application of each of three treatments with Systox, Woodstock, N.B., 1950.

Percentage Reduction			
Date	Treatment A*	Treatment B	Treatment C
July 18	100	80	100
July 24	92	67	74
August 1	74	0	0
August 9	67	6	40
August 16	58	0	10
August 23	51	5	56
August 31	38	63	63

Treatments B and C gave inconsistent results. On July 18 and 24 reduction of the aphid population on these plots was efficient, but this was the time aphids were establishing themselves on the plants and the results cannot be conclusive. After July 24 the reduction of aphid population became erratic.

The report of the tuber analyses received from Geary Chemicals was as follows:—

Treatment	Systox in Parts per Million
A	0.5
B	1.0
C	0.25
D	0.0

When compared with check plots of other experiments at the Woodstock field station, the check plots of the Systox experiment had a much lower aphid population. This may be accounted for in part by the fact that the Systox experimental area was planted approximately 16 days later than the others, thereby delaying the establishment and build-up of aphids on the plants.

In a crop such as potatoes, the amount of insecticide stored in the tubers is of first importance. The analysis indicates that the least amount of Systox was stored in the tubers when the plants were sprayed one week after emergence; the greatest amount of Systox storage occurred when the seed pieces were dipped in the formulation and immediately planted. The latter treatment was the least satisfactory from a commercial standpoint, for the aphid population was not efficiently reduced.

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\* See text.

## SOME RESULTS OF AN INVESTIGATION OF THE REPELLENT EFFECTS OF DDT TO THE HONEY BEE<sup>1</sup>

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### INTRODUCTION

As a part of the programme of the Legume Research Committee in Ontario it became desirable to know if DDT, when applied to legume forage crops, particularly those grown for seed, caused any significant repellency to, or mortality among, bees and other pollinators that would normally visit the crop; and it was the object of the present work to study primarily such repellency and secondarily such mortality as might be caused.

It is intended that a full account of this work, which has extended over two years, shall appear elsewhere, when the results have been more fully co-ordinated and analysed; but it seemed that a brief account might be of value at this time.

A compilation of the literature on honey bee toxicology has recently been published by Musgrave and Salkeld (1950). There are indications of difference of opinion about repellency and mortality. Here it may be remarked that in making comparisons of results of different investigators it is of the utmost importance to take into account their terms of reference and the conditions of the test; in particular, laboratory results cannot necessarily be compared with field results, even when obtained by the same investigator.

### MATERIALS AND METHODS

*Insecticides* used were:

- (i) a wettable powder containing 50% DDT which was diluted in water;
- (ii) a stock emulsion containing 25% DDT which was diluted with water; and
- (iii) a dust containing 3% DDT which was applied in that form.

*Applicators* used were a John Bean "Spartan" sprayer mounted on wheels and equipped with a gasoline engine; a small hand potato duster; and a Messinger Traction single-wheel duster.

The method, basically, was to determine by a simple counting method the extent to which bees were working a particular area, and then to treat the area with various dusts and sprays, leaving certain parts untreated to form checks. Further assessments by counting then determined to what extent bees were repelled. Naturally, it was desirable to make whatever allowances possible for factors such as the weather, the condition of the crop, and the area of test.

Each experimental area was therefore divided into plots and these plots were allotted different treatments. Some experiments were designed as randomized blocks and the results subsequently analyzed statistically using analysis of variance or analysis of co-variance. The analysis of co-variance, it was felt, was a readily available method of allowing for the multifarious factors such as weather and crop variation inherent in a problem of this kind.

In the hope of avoiding the labour and possible lack of preciseness and accuracy of the simple counting method, attempts were made to devise means of marking bees or plots with fluorescein (Musgrave 1949, 1950). These methods showed considerable promise but could not be brought to fruition in time to use in this investigation. It is felt that the counting method used gave a reliable assessment of honey bee and wild pollinator activity.

<sup>1</sup>Part of the programme of the Ontario Legume Research Committee.



## CONCLUSIONS

## REPELLENCY

Work in 1949 was done on small plots of red clover and sweet clover and fairly full weather records were kept. In some experiments a plot called a "weather check" was used: it was placed at a little distance from the main plots in each experiment and was intended to act as an indicator of the effect that weather alone was having on bee workings. Observations on one such weather check suggested that in the main experimental area both the check plots and the treated plots were repellent for a short time after the treatment. That is to say the check plots had some repellency by virtue of their position next to the treated plots. The work of 1950 seems to confirm this idea.

The conclusion from the 1949 experiments was that DDT sprays made from an oil stock emulsion or from a wettable powder, and applied at standard recommended rates of application, caused at most a slight and temporary repellency to honey bees.

The work in 1950 was on a more elaborate scale; dust treatments were included, and counts of wild pollinators were made. It has been possible to subject most of these results to an analysis of variance or an analysis of co-variance. Dusts proved very difficult to work with as it was found impossible effectively to control drifting. The sprays and dusts were applied to alsike clover at very heavy rates of application far in excess of the recommended rate, and to sweet clover, in one experiment, at the standard rate. It has seemed reasonable to conclude that the work of 1950 confirms that of 1949: *DDT causes, at most, a slight temporary repellency to honey bees.*

Standard recommended rates taken as:

2 lbs. of a 50% wettable powder per acre, i.e. 1 lb. actual DDT per acre, or 30–35 lbs. of a 3% dust per acre, i.e. 1 lb. actual DDT per acre.

Finally, it is of note that seed yields from one heavily treated experimental area showed no statistically significant difference between check and treated plots; the difference actually was considerable: the higher yield coming from the *treated* plots. This argues against any long term repellency on the treated crop.

## MORTALITY

The determination of pollinator mortality in the field is fraught with innumerable difficulties, many of which have, at most, been only partially surmounted. Little is known of normal bee mortality, which must be a variable factor in itself. In one of the experimental areas in this work an assessment was made of bee mortality by placing a sheet of white canvas in front of a hive placed at the side of the experimental area. The dead on the white canvas were counted at intervals. Such a method can give only a very rough idea of such bee mortality as might be occurring; for there is no check to act as a comparison and no means, as yet, of determining with certainty to what the mortality of any dead bees might be ascribed. For example, mortality might be due to ill-health in the colony due to parasitism or to insecticidal treatments on some other crop, to senility, or to skunks.

It was therefore decided to assess the bee mortality by an examination of the hives towards the end of the season. Five hives placed at the sides of experimental areas were examined, one by an independent observer. All were found to be in a very healthy condition. This may be regarded as an indication that such bee mortality as was occurring was not serious in extent (Townsend, 1950).

Our findings would seem to be in general agreement with those of Häfliger (1949), McGregor and Vorheis (1947) and Way and Synge (1948).

It should be added that recent verbal reports (Townsend, 1950) of work in the U.S.A. indicate that application of dusts from aeroplanes may cause mortality to bees because of drifting into the hive entrance.

The work reported in this note was done with the considerable help of Miss E. H. Salkeld.

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### "TAGGING" ROOT MAGGOT FLIES (*HYLEMYA* SPP., *ANTHOMYIDAE*) BY MEANS OF RADIOACTIVE PHOSPHORUS.

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Root maggots are serious pests of turnips, cabbages, cauliflowers and radishes in Ontario and other parts of northern North America. In Ontario the dominant species is *Hylemya brassicae* Bouché. Two other species *H. floralis*<sup>2</sup> Fall, and *H. cana* Macq. (*H. cilicrura* Rondani) are present but their specific separation from each other in the immature stages is very difficult. For the time being I have lumped these two together. Since it is not possible to identify the adults of any of these species in the field with certainty, accurate observations on these flies are lacking.

The purpose of the present preliminary investigation was to determine if radioactive phosphorus ( $P_{32}$ ) could be used to tag these flies. *PROCEDURE* — A plot of early turnips (rutabagas) sown in late May 1950 on the farm of Mr. Wm. Smith was used. The farm is situated in Beverly Twp., Wentworth Co., Ont. Such a heavy root maggot population developed early in the season that most of this field was ploughed up and resown on June 29 leaving only our 15 ft.  $\times$  60 ft. plot of the original crop.

Parts of three rows of similar-looking turnips were selected and staked off so as to contain 24 plants in each series. These were marked respectively, — "strong", "weak" and "check".

<sup>1</sup>Grateful acknowledgement is made to Dr. R. S. Brown, Head of the Department of Chemistry, O.A.C. for his generous co-operation in calculating the dosage, supplying the  $P_{32}$  and counters and supervising the testing; to Prof. A. W. Baker, Head of the Department of Entomology and Zoology and to my field assistant, Mr. R. J. Walsh.

<sup>2</sup>*H. trichodactyla* Rondani (see Brooks, *Can. Ent.* 83(5)).

On July 4, a 2 ml. solution containing 1 millicurie of  $P_{32}$  was received by my collaborator Dr. R. S. Brown, who further diluted this solution to a convenient volume and poured it into the soil at the base of the turnips. In this way the "strong" series received a total of 0.8 millicurie of  $P_{32}$ , the "weak" series a total of 0.2 millicurie of  $P_{32}$  and the "check" was left untreated.

On July 13, one half of each series was covered with a cheesecloth cage. The cages were examined twice weekly until August 14 when they were removed. Captured flies were tested for radioactivity either in the field by means of a portable Geiger-Muller counter or in the laboratory of the Department of Chemistry by means of the larger, more sensitive counter.

Four stations for net sweeps were established in the same field. The nearest one included the treated turnips; the farthest one was about 300 yds. away. Anthomyid flies, captured by sweeping ordinary insect nets over the measured courses, were killed and examined for radioactivity as before. Sweeps were taken over an average distance of 150 yds. per station and on these dates: July 18, 27; August 3, 7, 10, 14, 16 and 24.

### RESULTS — A. RADIOACTIVITY TESTS

1. *Uncaged turnips*: "strong series"—on July 19 one turnip and its surrounding soil were removed and examined. There were: four puparia (one *H. brassicae*, three *H. cana floralis*) and larvae (one *H. brassicae*, one *H. sp.*); all six specimens were strongly radioactive.

2. *Caged turnips*: "strong" series; a total of 10 anthomyid flies was obtained. Of these three were radioactively positive:

July 27 — one male *H. brassicae*

July 21 — one male *H. brassicae*

one male *H. cana*

"Weak" series: six anthomyid flies found were all negative;

"Check" series: three anthomyid flies obtained were all negative.

3. *Sweeps*: An average of eleven anthomyids per sweep was obtained at the stations. None of these were radioactively positive.

### B. OTHER OBSERVATIONS

A large population of aphids (not identified but probably *Rhopalosiphum pseudobrassicae* (Davis)) developed on the leaves of the caged turnips of the three series. Aphids were scarce on the nearby uncaged turnips.

**DISCUSSION AND SUMMARY** — This preliminary work shows that it is possible to tag root maggot flies by applying radioactive phosphorus to the soil around the root of the host plant. A dose of 0.2/24 millicurie of  $P_{32}$  per plant yielded no positive flies whereas a dose of 0.8/24 millicurie of  $P_{32}$  resulted in 3 positive flies as well as 6 positive immature forms. It is possible, therefore, that radioactive tagging may be an aid in the study of root maggot flies and their parasites with respect to their dispersal, local distribution and habits.

A major difficulty in the way of successful application of this tagging technique, is how to concentrate the precious  $P_{32}$  so that much of it is picked up by the root maggots. The natural population of root maggots on the Smith farm in the summer of 1950 did not average more than five per turnip at any one time. perhaps it will be possible to culture maggots on an artificial medium treated with  $P_{32}$  or to collect young root maggots from untreated roots and transfer them to treated roots. Even if this is achieved, effective numbers of tagged adults at any given time will be relatively low since all stages of the life history are variable in duration.



## STUDIES ON THE USE OF DDT AND METHOXYCHLOR FOR HOUSEFLY AND HORNFY CONTROL WITH ESPECIAL REFERENCE TO RESIDUES IN MILK

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The data presented in this paper are the result of co-operative studies conducted during the past two years by the Departments of Entomology and Chemistry of the Ontario Agricultural College. It was felt, at the time these studies were undertaken, that more information on DDT and methoxychlor residues occurring in milk as a result of cow and/or barn spraying was desirable. For convenience of presentation the various studies are reported as separate parts of this paper.

### ACKNOWLEDGMENT

The authors are indebted to F. E. Roadhouse for assistance in connection with the analytical work.

### I. THE DDT CONTENT OF MILK AS A RESULT OF COW AND BARN SPRAYING

Early in 1949 considerable opposition (Dunbar 1949; U.S.D.A. 1949) arose to the use of DDT on dairy cattle and in dairy barns. Howell et al (1947) used abnormally large amounts of DDT on dairy cows — daily applications of 2 quarts of 5 per cent DDT in water suspension per animal. The milk was analyzed daily, the minimum DDT content (33.6 p.p.m.) occurring on the twentieth and final day of spraying. Three and one-half months later the milk still contained 1.3 p.p.m. Where cows were sprayed fortnightly with 0.25 per cent DDT wettable powder suspension or emulsions, the milk was found to contain from 0.2 to 2.5 p.p.m. of DDT.

Carter et al (1949) made weekly analyses of the milk from commercial dairy herds sprayed five times, during an approximate 5 months period, with a 0.5 per cent wettable powder suspension of DDT. The milk during this period showed DDT contents ranging from 0.1 to 2.0 p.p.m., with an average of approximately 0.5 p.p.m. Six sprayings, during the same period, with a 0.25 per cent wettable powder suspension resulted in DDT contents of from 0.1 to 1.5 p.p.m., with an average of approximately 0.3 p.p.m.

Carter et al (1949) have reported data pertaining to the DDT content of milk following one high-pressure spraying of cows with a 0.4 per cent wettable powder suspension. The cows were sprayed over the entire body to the point of saturation, and there was considerable run-off. One cow was hand-milked, without particular precautions to prevent external contamination of the milk. Amounts of DDT averaging 1.3 p.p.m. appeared in the milk over a period of approximately 5 weeks. The maximum content (3 p.p.m.) was shown by the first sample, which was taken on the second day after spraying. The last sample taken still contained 0.4 p.p.m.

In view of the fact that the above studies apparently involved only the spraying of the cows, it was considered of interest to study the combined effect of spraying both the cows and the dairy barn on the DDT content of the milk. The O.A.C. dairy herd was used for this

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experiment. Unfortunately a DDT spray had been applied approximately one month before the first treatment of this study. However, for purpose of blank determinations composite milk samples were obtained from two other herds where no previous DDT or DDD treatments had been used in 1949.

The O.A.C. dairy herd is a mixed herd containing pure-bred representatives of the Holstein, Ayrshire, Jersey, and Guernsey breeds. The herd was pastured except during milking hours. Milking was done by machine, the usual precautions, such as washing the udders, etc., being observed to prevent contamination of the milk.

### SPRAYING PROCEDURE

A water-suspension of a 50 per cent wettable DDT powder was applied at approximately 250 lbs. pressure by means of a small power sprayer. In the barn the DDT was used at the rate of 1 lb. to 5 gallons of water, the entire barn being sprayed to the run-off point. Care was exercised during spraying to keep the spray out of drinking bowls and mangers in order to avoid contamination; and, immediately after spraying, the drinking bowls were emptied and the mangers washed. The cattle were sprayed on the same day as the barn, the DDT powder being used at the rate of 1 lb. to 20 gallons of water. About one-half gallon of spray was used per animal with wetting to the base of the hair. This treatment resulted in fly control up to 3 weeks, the intervals between sprayings being governed by the recurrence of an annoying abundance of horn flies.

### SAMPLING

Samples were taken on the day previous to sprayings and on the first, second, and third days, respectively, after spraying, and thereafter at weekly intervals. In a few instances circumstances developed which prevented a strict adherence to this schedule.

Quart milk bottles which previously had been thoroughly cleaned, dried and capped were used for collecting the milk samples. These bottles were filled to within about 2 inches of the top, 2 ml. of formalin were added as a preservative, and the bottles were stored in a refrigerator until the time of their analysis. Each sample represented a composite from a number of cans.

### METHODS OF ANALYSIS

The method of Schechter et al (1947) was used for the extraction of DDT and fat from the milk, and the subsequent separation of the fat from the DDT. The DDT was determined colorimetrically by the method of Schechter et al (1945).

The standard curve necessary for the calculation of DDT-content was determined by using a sample of the same technical DDT as was used for spraying purposes. The density measurements were made at 600 m. $\mu$ . using a Coleman Universal Model 11 spectrophotometer, with matched round cuvettes. Preliminary studies had indicated that averaging the results from readings made at 600, 620, and 640 m. $\mu$ ., showed no significant difference as compared with the results from the readings made at 600 m. $\mu$ . Blank analyses were run on samples from the two control herds, referred to above, and the results were applied as corrections to the values obtained on samples from the sprayed herd. Results on the control samples from the two herds were the same numerically and were both very low.

### RESULTS

The results of the determinations on samples of milk from the O.A.C. dairy herd are shown in Table 1. The same data are shown graphically in Fig. 1.

TABLE 1

DDT-CONTENT OF MILK AS A RESULT OF SPRAYING COWS AND BARN

<i>First Spraying</i> (July 26th, 1949)		<i>Second Spraying</i> (Aug. 17th, 1949)	
<i>Sampling Time</i> (Days after Spraying)	DDT (p.p.m.)	<i>Sampling Time</i> (Days After Spraying)	DDT (p.p.m.)
-1*	.6	1	1.6
1	1.3	3	1.1
2	.9	7	1.0
3	.8	14	.8
15	.7	21	.7
20	.6	28	.5

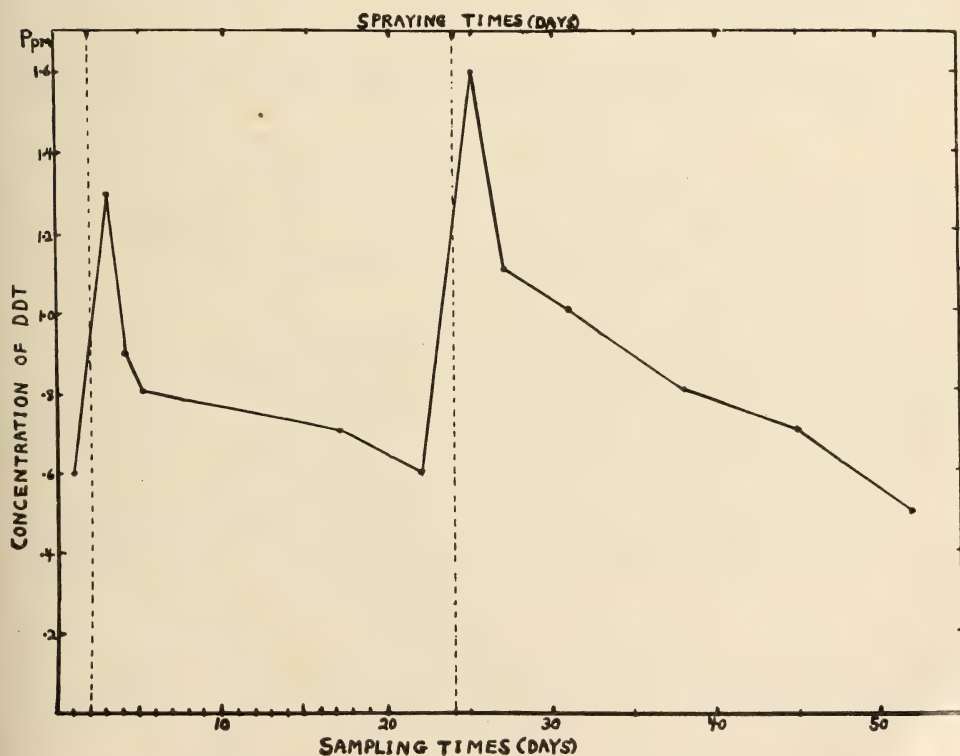


FIGURE 1. — DDT-CONTENT OF MILK SAMPLES.

\*First sample taken one day before spraying.



## DISCUSSION

We attribute the initial DDT residue of 0.6 p.p.m. to the fact that the cows had been sprayed approximately one month prior to the taking of the first sample. Very good support is lent this assumption in that twenty days after the first spraying of this study the DDT-content of the milk was also 0.6 p.p.m., and twenty-eight days after the second spraying it was 0.5 p.p.m. As pointed out above, blank analyses run on samples of milk from the two control herds gave very low values.

The data show a very marked increase in the DDT-content of the milk twenty-four hours after spraying, with a quite appreciable drop during the succeeding forty-eight hour period. From this time on the drop was much more gradual. However, one month after spraying the milk still contained 0.5 p.p.m. The results indicate that where both cattle and stables are sprayed with DDT, appreciable amounts may occur in the milk for a considerable time after spraying.

The presence of the DDT in the milk could be due to external contamination occurring during milking from udders, milking equipment, etc., or to actual secretion in the milk of DDT as a result of ingestion of spray residues left on feed troughs, by licking, by absorption through the skin of the animal, etc., or to a combination of these factors.

## II. THE DDT CONTENT OF MILK AS A RESULT OF BARN SPRAYING

Early in 1949 the U.S. Department of Agriculture (1949) recommended that the use of DDT sprays for controlling insects on dairy cattle and in dairy barns should be discontinued. However, the evidence upon which the objection to the use of DDT for barn spraying was based, was none too conclusive. This prompted the launching of experiments by ourselves and other workers to secure additional information on this subject.

At the time of the above U.S. recommendation, Laake (1949) reported that DDT could be found in milk as a result of the application of DDT insecticides to dairy barns, even though no DDT was applied directly to the animals. Early in 1950 Harris et al (1950) published the results of their studies on this problem. Four dairy barns were sprayed, the walls and ceilings being thoroughly covered. Feed troughs and drinking fountains were covered with tarpaulins during the spraying. Seven samples were taken in each barn, 2 before spraying, 1 on the day of spraying (evening milking) and 1, 3, 7, and 14 days after spraying. The cows were on pasture for the duration of the sampling period, except during milking. Of 28 samples analyzed 7 showed the presence of from .03 to .05 p.p.m. of DDT. Four of the seven contaminated samples came from the barn where the least sanitary milk handling methods were followed.

Since the completion of the experimental work of this paper, Frear et al (1950) and Claborn et al (1950) have reported their results. Frear and his co-workers found a small amount of DDT in the milk of dairy cows which had been housed, fed, watered and milked in barns sprayed with DDT. In most cases the maximum amounts were found 1 or 2 days following the treatment and, with one exception, did not exceed 0.5 p.p.m. They point out that, from the data available, it is not possible to state with certainty how the DDT got into the milk, but that it is quite obvious that the DDT found in the milk on the day the barns were sprayed, must have been the result of mechanical transfer, since the cows were not in the barn at the time of spraying and were not returned to their stalls until immediately before the milking operation.

Claborn and his associates (1950) made a study of the source of milk contamination when dairy barns were sprayed with 2.5 per cent DDT. Their work indicated that spray residues left on the feed troughs resulted in the secretion of the insecticide in the milk, and that it did not get into it as a result of careless handling of the milk or milking equipment. When troughs were partly covered the contamination was moderate, and when they were completely covered or thoroughly washed, contamination was negligible or existed only as traces. They also found that no contamination resulted from inhalation of the insecticide by the cows.

The work of this study, in which the O.A.C. dairy herd was again used, involved the effect of barn spraying on the DDT-content of milk during the pasture season of 1950. The same procedures for barn spraying were followed as in the previous year's work reported in Part I of this paper. Up to three weeks control was obtained for houseflies.

During the experiment an emulsion of 10 per cent piperonyl butoxide and 1 per cent pyrethrum was used on the cows themselves at a dilution ratio of 1 part emulsion with 9 parts of water. Approximately 2 pints were applied with a Spartan sprayer as a fine mist over each animal. This application gave control for a period averaging six days. The cattle were sprayed when the hornfly population reached twenty per animal.

During the spraying of the barn, care was again exercised to keep the spray out of drinking bowls and mangers in order to avoid contamination; and, immediately after the spraying, the drinking bowls were emptied and the mangers washed. However, the feed troughs and drinking fountains were not covered by tarpaulins during the spraying as in the work of Harris et al, referred to above; since it was felt that it would be difficult to get farmers and commercial spray operators to follow this procedure, and the aim in this study was to simulate conditions which would likely obtain in spraying on the average dairy farm. Milk samples were again taken on the day previous to sprayings and on the first, second, and third days, respectively, after spraying and thereafter at weekly intervals; except in those instances where circumstances prevented a strict adherence to this schedule.

#### METHODS OF ANALYSIS

Analyses were made by the methods of Schechter et al., as used in the previous year's work, with the modifications found by Clifford (1947) to be necessary for the determination of small amounts of DDT, such as were involved in this study. The standard working curve was set up by adding known amounts of the same technical DDT, as was used for spraying purposes, to blank milk samples and analyzing them. Recovery determinations, based on the addition of known amounts of DDT to blank milk samples (taken before DDT spraying was begun, and stored) were made from time to time during the course of the study. Spectrophotometric measurements were made at 600 m. $\mu$ . using a Coleman Universal Model 11 Spectrophotometer, with matched round cuvettes.

One of the modifications introduced by Clifford (1947) to prevent loss of DDT during nitration was the addition of 10 mg. of oleic acid just previous to the nitration. Clifford recommended U.S.P. oleic acid. Samples of U.S.P. grade oleic acid obtained from two different sources both resulted in off-colours (brownish shades) on colour development, even when all the other modifications recommended by Clifford were followed. A third sample of a redistilled grade also gave some off-colour, but considerably less. When this latter product was redistilled under vacuum a satisfactory product was obtained. However, in order to guard against any trouble from this source the purified product was kept in a refrigerator and the oleic acid-benzene solution freshly prepared at time of use.

#### RESULTS

The results of the determinations on milk samples are shown in Table 2. The same data are shown graphically in Figure 2.

TABLE 2

## DDT-CONTENT OF MILK AS A RESULT OF BARN SPRAYING

Sampling Time (Days After Spraying)	DDT (p.p.m.)	Sampling Time (Days After Spraying)	DDT (p.p.m.)
-21*	0	<i>Third Spraying, August 9th, 1950.</i>	
-15*	0	1	.04
- 8*	0	2	.03
		3	.03
<i>First Spraying, June 13th, 1950.</i>		14	.03
1	.05	27	.01
2	.06	34	.01**
3	.06		
7	.03	<i>Fourth Spraying, September 13th, 1950.</i>	
28**	.03	1	.06
		2	.06
<i>Second Spraying, July 12th, 1950.</i>		3	.05
1	.06	7	.00
2	.05		
3	.05		
12	.05		
21	.01		
27**	.02		

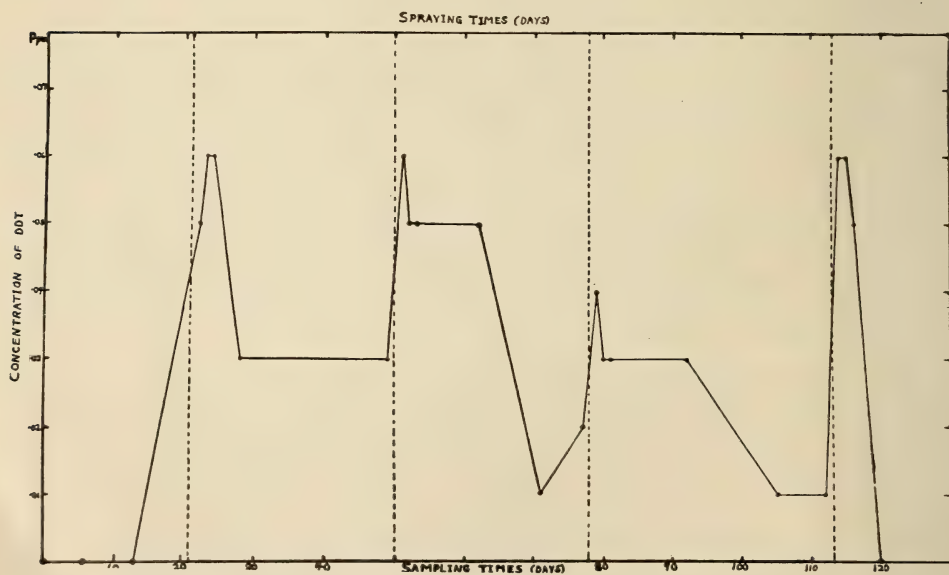


FIGURE 2. — DDT-CONTENT OF MILK SAMPLES (BARN SPRAYING)

\* Samples taken before first spraying.

\*\*Samples taken 1 day previous to next spraying.



## DISCUSSION

The data show the presence of relatively minute amounts of DDT in the milk throughout the season, after the beginning of spraying. The highest amounts were always found during the first three days following a spraying, the amounts then tending to drop off until the time of the next spraying.

If the highest DDT-content occurring at any time (.06 p.p.m.) be compared with the highest content found at any time during the previous year (1.6 p.p.m.), when both the cows and the barn were sprayed, it is seen that the previous year's highest value is nearly 27 times the present year's highest value. Likewise, if the lowest values recorded in the respective years (.01 and .5) be compared, the previous year's value is 50 times that of the present year. It thus appears that cow spraying is a vastly more serious source of DDT-contamination in milk than is barn spraying. The results indicate that when barn spraying is conducted with ordinary precautions DDT-contamination of milk from this source is not likely to prove at all serious.

### III. THE METHOXYCHLOR CONTENT OF MILK AS A RESULT OF COW AND BARN SPRAYING

When the U.S. Department of Agriculture recommended that the use of DDT sprays on dairy cattle and in dairy barns should be discontinued they suggested methoxychlor as one of several acceptable substitutes because of its relatively non-toxic nature.

The manufacturers of methoxychlor reported that it showed little or no tendency to appear in the milk of properly-treated animals. Carter et al (1949) collected milk samples at weekly intervals from two herds of dairy cattle which had been treated 5 or 6 times during the season with a 0.5 per cent wettable powder suspension of methoxychlor. When these samples were analyzed for organic chlorine content only 3 of 42 samples showed an amount greater than that of the blank samples from untreated animals, the average values being only 0.1 p.p.m. These workers concluded that their experiments "gave no conclusive indications" that methoxychlor is eliminated in the milk of treated animals.

Since the chloride method for methoxychlor is inadequate for determinations in the low concentration range, a reinvestigation of this problem using a more sensitive and specific colorimetric procedure seemed desirable. In addition very little had been reported on this subject by independent sources.

This study involved the combined effect on the methoxychlor-content of the milk of spraying both cows and dairy barns. Two Holstein herds located near Guelph were used for this experiment, the cows being on pasture except at milking time. Milking was done by machine and the usual precautions to prevent contamination of the milk were observed.

#### SPRAYING PROCEDURE AND RESULTS

The cows were thoroughly wetted with a water suspension of 50 per cent methoxychlor at the rate of 1 lb. in 20 gallons. Control of hornflies was maintained for three weeks.

The walls and ceilings of the barns were sprayed to the point of run-off with 50 per cent wettable methoxychlor at a concentration of 1 lb. in 5 gallons of water. This treatment proved effective against houseflies for a period of three weeks.

Throughout this experiment the procedure and precautions were similar to those reported in Part I. of this paper. This was also true as to sampling, except that circumstances prevented a strict adherence to schedule with respect to times of sampling.

#### METHODS OF ANALYSIS

Analyses were made by a method proposed by A. J. Lehman and E. P. Laug of the U. S. Food and Drug Administration. The preliminary extraction of methoxychlor and fat from the milk is similar to the method of Carter (1947) for DDT. However, the method of Schechter et al (1947) for the separation of DDT from fat by extracting the latter with sulphuric acid (used in our DDT-residue work) cannot be used for methoxychlor which is itself soluble in the acid.

Accordingly, Lehman and Laug proposed a different procedure. The sample is treated with ethanolic KOH which saponifies the fat and dehydrohalogenates the methoxychlor. The latter is then separated from the soap by extraction with petroleum ether. The saponified fat remains in the alcohol-water layer and is discarded. The petroleum ether fraction, which contains some unsaponifiables, is nitrated, washed, and treated with sodium methylate reagent according to the familiar Schechter (1945, 1947) procedure.

During the course of our study a paper was published by Prickett, Kunze and Laug (1950), which essentially embodies the procedure of Lehman and Laug used in our work. The published procedure, however, introduces certain modifications such as: the ethyl ether extract of the nitrated products is thoroughly washed with 10 per cent KOH rather than 5 per cent NaOH, and after evaporation of the solvent the nitrated residue is heated for a 20-minute period. The first of these modifications had been suggested previously by Clifford (1947) in connection with his studies on the analysis of DDT residues, and he had recommended heating the nitrated residue for a one-hour period following evaporation of the solvent. Based on Clifford's suggestion, 10 per cent KOH was used throughout in our work. The 20-minute heating of the nitrated residue was followed in the case of the samples from herd B. Prickett et al (1950) also added 5 to 10 mg. of stearic acid to the petroleum ether extract of the ethanolic KOH hydrolysate and then blew off the solvent under a gentle current of air on the steam bath. The stearic acid is added to prevent the loss of the somewhat volatile dehydrochlorides of methoxychlor by volatilization during solvent evaporation. In our procedure the petroleum ether was evaporated off over a water bath maintained at 40–45°C or below, using a current of air to accelerate the evaporation. This was in accordance with the original procedure of Lehman and Lang.

The standard working curve was set up by adding known amounts of methoxychlor (commercial product recrystallized 3 times from ethyl alcohol) to blank milk samples (taken before methoxychlor spraying was begun and stored) and analyzing them. Recovery determinations, based on the addition of known amounts of methoxychlor to blank milk samples, were made from time to time during the course of the study. Spectrophotometric measurements were made at 540 m. $\mu$ . with the same instrument as described earlier. Reagent grade chemicals were used throughout this study, except for the preliminary extraction of the milk. Solvents were distilled once from all glass apparatus.

It should be noted that this method is not specific for methoxychlor and does not differentiate between methoxychlor and either of the isomers of DDT. Hence great care was exercised to ensure that no DDT was used on any of the cattle or about the barns.

#### DISCUSSION OF RESULTS

The results of the determinations on samples of milk from the two dairy herds are shown in Table 3. In the first three days' samples the 72-hour sample commonly was the lowest, in one case showing no methoxychlor at all. In only one case was a concentration of methoxychlor greater than 0.05 p.p.m. found. With one exception the data show no methoxychlor in milk samples taken more than three days after spraying.

Prickett et al (1950) have indicated the limit of quantitative sensitivity of their method to be about 5 micrograms in 100 ml. of milk, which is equivalent to 0.05 p.p.m. Thus the accuracy of values lower than 0.05 p.p.m. recorded in Table 3 may be questioned. However, recovery determinations, made from time to time in the 0.05 p.p.m. range showed good agreement with the standard curve. Furthermore, all methoxychlor values in Table 3 down to 0.03 p.p.m. correspond to the presence of visible pink colours in the extracts which were read colorimetrically, and therefore should be measurable in the spectrophotometer. Extracts giving values lying below 0.03 p.p.m. showed no visually detectable pink colours.

The minute amounts of methoxychlor found in the milk, coupled with its relatively non-toxic nature, would indicate this insecticide to be a very safe one for use on dairy cattle and in dairy barns.

TABLE 3

METHOXYCHLOR CONTENT OF MILK AS A RESULT OF COW AND BARN SPRAYING

HERD A		HERD B	
Sampling Time (Days After Spraying)	methoxychlor (p.p.m.)	Sampling Time (Days After Spraying)	methoxychlor (p.p.m.)
-26*	0.00	-24*	0.00
-19*	0.00	-17*	0.00
-12*	0.00	-10*	0.00
- 5*	0.00	0**	0.00
0**	0.00		
<i>First Spraying June 10/50</i>		<i>First Spraying June 8/50</i>	
1	0.05	1	0.04
2	0.03	2	0.03
3	0.00	3	0.02
10	0.00	11	0.00
21	0.00	14	0.00
25**	0.00	20**	
<i>Second Spraying July 5/50</i>		<i>Second Spraying June 29/50</i>	
1	0.05	1	0.02
2	0.06	2	0.05
3	0.05	3	0.04
8	0.02	7	0.00
15	0.00	14x	
20**	0.00	21**	0.00
<i>Third Spraying July 25/50</i>		<i>Third Spraying July 21/50</i>	
1	0.05	1	0.03
2x		2x	
3x		3	0.03
14	0.00	14	0.00
21	0.00	20**	0.00
31**	0.00		
<i>Fourth Spraying August 25/50</i>		<i>Fourth Spraying August 11/50</i>	
1	0.05	1	0.05
2	0.04	2	0.05
3	0.02	3	0.03
15	0.00	25	0.00
		<i>Fifth Spraying September 9/50</i>	
		1	0.02
		2	0.03

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\* These samples taken previous to first spraying.

\*\*These samples taken within a 24 hour period prior to next spraying.

x A number of samples were lost due to mould development.



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## STUDIES ON THE USE OF LINDANE ON DAIRY CATTLE AND IN THE DAIRY BARN WITH RESPECT TO TAINTING IN CHEESE

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The following is a report of an experiment to determine whether any off-flavour would be apparent in cheese made from milk taken from a herd which had been sprayed with lindane in a lindane-treated barn.

This experiment seemed advisable because residues are found in the butterfat of milk taken from cows treated with the gamma isomer of benzene hexachloride (Bushland et al 1950) (Schwardt 1949). Canadian Cheddar cheese contains approximately 35% butterfat. No chemical determinations of spray residues were made.

One herd close to the College was sprayed on the afternoon of Monday, July 17th, 1950, with a suspension of 25% wettable lindane at a rate of 1½ lbs. to 80 Imperial gallons of water. The animals were thoroughly wetted. The barn was sprayed with a suspension of 1 lb. 25% wettable lindane in 8 Imperial gallons of water. Spray was applied to the point of run-off. In both cases the insecticide was applied at 250 lbs. pressure with a small Sparton sprayer.

Monday evening's and Tuesday morning's milk samples were brought to the O.A.C. and held over until Wednesday. Tuesday night's and Wednesday morning's samples were collected on Wednesday morning and the two lots were pooled in a vat of cheese. Bacteriologically, the milk was of exceedingly poor quality.

A similar sized vat of milk from the O.A.C. herd was used as a check vat.

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Cheese was made up from the two vats in the manner similar to that practised in Canadian cheese factories, and removed from the press the following day. It was then held from July 20th to July 28th, when it was examined. No taint due to lindane was apparent. On August 1st, the sample was again tested by three experienced judges and none could detect any foreign taint suggestive of lindane.

Though the flavour of the vat of cheese made from the above milk was somewhat affected by the poor initial quality of the milk, the flavour of the resulting cheese was not such that it would interfere with detecting the insecticide involved.

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## THE 1950 STATUS OF THE DUTCH ELM DISEASE IN CANADA<sup>1</sup>

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Since the discovery of the Dutch Elm Disease, *Ceratostomella ulmi* Buisman, in the Province Quebec in 1944, annual surveys have been conducted by the Division of Plant Protection with the co-operation of the Quebec Department of Lands and Forests and in Ontario with the co-operation of the Department of Agriculture, to delimit the area infected and to make all reasonable efforts to retard its spread.

At the close of the 1950 survey season the disease had been located in 45 counties in the Province of Quebec, which in fact, includes almost the entire area of the province where the elm is abundant, with the exception of the upper Ottawa valley and the counties of Huntingdon and Chateauguay south of the St. Lawrence river. It has been most severe on both sides of the St. Lawrence river from Montreal to Quebec and in the Richelieu, Yamaska and St. Francis river valleys, all of which lie southeast of the St. Lawrence.

The annual surveys in Ontario, starting in 1945, revealed no evidence of the disease until 1948 when 14 infected trees were located in six counties in the extreme eastern end of the province. Of the 14 only one, a tree located in the city of Ottawa showed definite symptoms of the disease, while in the other 13, which were dead or dying at the time of sampling, the Dutch Elm Disease fungus was saprophytic and did not contribute to their weakened condition. No signs of the disease were observed during the 1949 survey in Ontario but in May 1950, samples submitted from the city of Windsor were found to be infected.

An intensive survey of Essex County during the summer revealed a well established outbreak in the Windsor area and by the end of the season 91 infected trees had been found. Surveys were also carried on throughout southern and eastern Ontario and 15 additional trees in 8 counties were found to be infected, bringing the total for the year to 106. First records were obtained in the counties of Welland, Peel, Prince Edward, Leeds, Frontenac and Glengarry. It was also found in Carleton and Prescott although it had appeared in these two counties in 1948.

It would appear that natural spread from Quebec has been the source of infection in eastern Ontario as the disease has continued to spread slowly in spite of efforts to keep it under control. It would seem logical to assume that the Essex County outbreak had its source

<sup>1</sup>Contribution No. 87, Division of Plant Protection, Science Service, Department of Agriculture, Ottawa, Canada.

somewhere in the east Central States but there are no authentic records of distribution in that area, as applying to recent years. It is of interest to note that following the discovery of the disease in Windsor, a report of which was sent to Michigan State authorities, a local survey in the Detroit area located a number of infected trees during the summer of 1950.

Surveys have been conducted by the Division of Plant Protection in the Maritime Provinces for several years but no signs of the disease have been found.

The area in Canada now known to be infected extends from Windsor, Ontario to Quebec City. In Ontario, with the exception of the Windsor outbreak, the results of the survey appear to indicate that the disease is present in minor outbreak form as only one or two infected trees were found in the counties listed.

The only known insect vector in Eastern Ontario and Quebec is the native elm bark beetle, *Hylurgopinus rufipes* Eichh. but in Southern Ontario the European species, *Scolytus multistriatus* Marsh., has been discovered in several counties since 1948. The native bark beetle is also present in this area and unless every effort is made by civic authorities and individuals to maintain elms in a healthy condition, the disease may be expected to spread rapidly and cause the death of many trees. This would necessitate large expenditures for their removal, particularly in towns and cities where such dead trees would become definite hazards to persons and property.



## HESSIAN FLY SURVEY AT HARVEST TIME IN WESTERN NEW YORK, 1950

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During the summer of 1950 at wheat harvest time, as during the past 15 years, a survey was made of several insects of winter wheat in 21 counties of western New York. While the investigation was concerned primarily with the abundance of hessian fly, *Phytophaga destructor* (Say), the infestations of European wheat stem sawfly, *Cephus pygmaeus* (L.); the black grain-stem sawfly, *Cephus tabidus* (F.); and the wheat billbug, *Calendra* spp. were also recorded.

Fifty to 60 wheat plants were selected at random from each of 5 fields in each county. The sampling locations were picked also in random areas throughout each county, but each field was at least 5 miles from any other sampling station. From the sample of wheat plants taken at each station, 50 wheat stems were chosen at random for examination. In wheat resistance studies, the plant, rather than the stem, is used as a unit because of the genetic considerations involved. However, the basic unit of stem was used in the wheat harvest time survey because of the difficulty in distinguishing individual plants, especially in broadcast and seed-drill seedings. Furthermore, experience has shown that the per cent of stems infested at harvest time is more informative than the per cent of plants infested.

In the various samples, each stem was split apart with a scalpel and examined for sawflies, hessian fly, and *Calendra* spp. or wheat billbug. In most cases, some stage of the insects present could be found, but where the insects themselves were not located, other signs such as frass, empty puparia, and sawfly stem plugs were useful in identifying the insects which had been feeding in the stems. The percent of each insect under consideration was determined for each sample from each county. The maximum, minimum, and average per cent of hessian fly, wheat sawflies (both species were considered together), and wheat billbug were summarized for all the counties. These data are recorded in Table 1.



Table 1.

A summary of the infestations of hessian fly,<sup>1</sup> wheat sawflies,<sup>2</sup> and wheat billbug<sup>3</sup> in 21 counties of Western New York at wheat harvest time during 1950. July, 1950.

County	No. of Fields Sampled	Percent of Wheat Stems Infested by								
		Hessian Fly			Wheat Sawflies			Wheat Billbug		
		Avg.	Max.	Min.	Avg.	Max.	Min.	Avg.	Max.	Min.
Allegany	5	2.0	4.0	0.0	6.4	14.0	2.0	14.4	22.0	8.0
Catteragus	5	0.8	2.0	0.0	7.2	24.0	2.0	6.0	14.0	0.0
Cayuga	5	6.4	12.0	2.0	38.8	54.0	12.0	13.2	20.0	8.0
Chemung	5	5.2	12.0	2.0	7.6	16.0	2.0	8.8	20.0	2.0
Cortland	6	3.0	6.0	0.0	29.7	66.0	6.0	7.7	18.0	0.0
Erie	5	*8.4	18.2	2.0	12.4	32.0	2.0	24.8	32.0	16.0
Genese	5	*8.8	18.0	2.0	41.2	56.0	24.0	28.0	50.0	8.0
Livingston	5	*9.2	36.0	2.0	20.0	34.0	4.0	13.2	24.0	0.0
Monroe	5	6.0	12.0	0.0	12.0	16.0	6.0	15.6	40.0	0.0
Niagara	5	*20.4	46.0	4.0	24.0	54.0	0.0	18.4	52.0	0.0
Ontario	5	7.2	12.0	0.0	25.2	58.0	10.0	12.0	28.0	4.0
Onondaga	5	*10.0	26.0	0.0	32.4	40.0	6.0	9.2	20.0	0.0
Orleans	5	6.4	12.0	2.0	35.2	76.0	14.0	18.8	36.0	4.0
Oswego	5	*12.8	28.0	2.0	3.6	12.0	0.0	8.8	18.0	0.0
Schuyler	5	6.8	18.0	0.0	10.4	14.0	4.0	11.6	34.0	0.0
Seneca	5	*10.4	24.0	0.0	34.8	74.0	12.0	19.2	32.0	10.0
Steuben	5	7.2	22.0	2.0	6.4	8.0	2.0	8.8	14.0	4.0
Tompkins	5	5.6	16.0	0.0	21.6	50.0	6.0	12.8	26.0	4.0
Wayne	5	*19.2	38.0	6.0	11.6	24.0	6.0	6.0	12.0	2.0
Wyoming	5	6.0	14.0	0.0	8.8	16.0	4.0	5.2	10.0	2.0
Yates	6	6.0	14.0	2.0	7.7	26.0	2.0	9.7	30.0	2.0
Totals	107	7.9	46.0	0.0	18.9	76.0	0.0	12.9	52.0	0.0

It is evident from Table 1 that moderate to heavy infestations of hessian fly were found in 8 of the 21 counties surveyed. Seven of the 21 counties had maximum infestations of hessian fly of over 20 per cent. It should be remembered that only 50 per cent of the stems may be infested when 100 per cent of the plants are infested. Therefore a figure of 20 per cent infestation, based on per cent of infested stems in a large sample of infested plants, represents a heavy infestation of hessian fly.

If the infestations, during the past 5 years, of hessian fly, wheat sawflies and wheat billbug are compared, (see Table 2) it can be seen that the average infestation of hessian fly has nearly doubled over that of 1949 but is little different from that of 1947 and 1948. Such variation in populations of hessian fly are not unusual because during periods of heavy fly infestation populations of the parasites, *Platygaster hiemalis* (Fbs.) and *Eupelmus allyni* (French) also rapidly increase. This increase in the population of parasites is usually followed by a decrease in hessian fly infestation the following year. During years of small hessian fly infestation, the populations of parasites of this insect are small also. Wheat growers in New York also contri-

<sup>1</sup>*Phytophaga destructor* (Say).

<sup>2</sup>*Cephus pygmaeus* (L.) and *Cephus tabidus* (F.) although most of the species found were *C. pygmaeus* (L.).

<sup>3</sup>*Calendra* spp.

\*Moderate to heavy infestations.

Fifty stems were examined from each field.

bute to large infestations of hessian fly in some years by ignoring the fly-free date in years favorable for early plowing. On the other hand, early fall rains often delay field activities so that growers are prevented from planting before the fly-free date. During such wheat growing years, the infestation of hessian fly remains normal.

Table 2.

A comparison in per cent of the average infestations of hessian fly, wheat sawflies and wheat billbug in Western New York during the past five years.

Year	No. of Counties Surveyed	Avg. Infestation for W. New York Per County in Percent		
		Hessian Fly	Wheat Sawflies	Wheat Billbug
1950	21	7.9	18.9	12.9
*1949	13	4.2	4.5	9.8
*1948	17	9.8	—	—
*1947	21	6.1	—	—
*1946	10	2.5	4.2	3.2

As may be seen in Table 2, the infestations of wheat sawflies and wheat billbug have increased to dangerous and destructive levels since 1946. The increase in sawfly and billbug infestations is probably due to the more prevalent practice of seeding winter grain with legumes. As a result, the infested stubble cannot be plowed under in the fall as in the accepted practice in controlling these wheat insects.

*Summary.* A harvest time survey of winter wheat in 21 counties of western New York indicated that a moderate to heavy infestation of hessian fly was present in that area and that recommendations concerning the fly-free date and clean cultural practices should be followed closely by the growers of that area in order to prevent any serious outbreaks of hessian fly in the future.

A study of the figures of the past surveys of the last 5 years also shows a large increase in the infestations of sawflies and wheat billbug.



## A SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1950<sup>1</sup>

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### INTRODUCTION

This summary has been prepared from regional reports submitted by officers of the Division of Entomology, provincial entomologists, officers of the Division of Plant Protection, and university professors. In general, common names used are from the April, 1950, revision of the list approved by the American Association of Economic Entomologists. Common names other than these are accompanied by technical names.

<sup>1</sup>In co-operation with the Bureau of Entomology and Plant Quarantine.

<sup>2</sup>Contribution No. 2783, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Editor of *The Canadian Insect Pest Review*.

In previous years this summary contained a section "Forest and Shade Tree Insects", which was reproduced with minor revision from reports prepared by the Forest Insect Investigations Unit of the Division of Entomology. It is regretted that no section of this nature is included herein due to the fact that the summary was compiled earlier than usual and the information was not available. It is regretted also that information on insect conditions in Newfoundland was not available at the time of writing.

#### GENERAL FEEDERS AND MISCELLANEA

**BEET WEBWORM.**—The beet webworm was apparently less abundant than in 1949 in Saskatchewan. Slight damage occurred in flax fields at Davidson; large numbers occurred in summerfallow at Cheviot, and reports were received from Rockhaven and Doddsland, west and north of Saskatoon. Light to moderate infestations were general on sugar beets throughout the Altona area of Manitoba late in July. A light outbreak occurred during mid-August in southwestern Manitoba, where some fields of flax were partially defoliated. Little damage was done to garden crops.

**BLISTER BEETLES.**—*Lytta* sp. caused minor damage to broad beans at Grand Forks, and *Epicauta oregona* Horn. was very evident on vetch in the Soda Creek area of British Columbia. A single field of sugar beets was severely attacked by *Epicauta maculata* (Say) at Cranford, Alta; *Lytta nuttalli* Say occurred in a few localized infestations on caragana and vetch, and severely defoliated a patch of *Astragalus* sp. at Lethbridge. Damage was negligible in Saskatchewan, less than in the preceding three years. *Lytta sphaericollis* Say severely damaged honeysuckle at Glenside. *E. maculata* was reported from Swift Current, and *Epicauta pennsylvanica* (Deg.) caused light damage to beans, caragana, and honeysuckle at Saskatoon. *Epicauta subglabra* (Fall.) fed lightly on alfalfa leaves north of the Hudson Bay district and *Meloe* sp. occurred on alfalfa near Cherry Ridge. *E. subglabra* and *Epicauta fabricii* (Lec.) occurred in small numbers in Manitoba but were very destructive to caragana at Morden. *Epicauta murina* (Lec.) was conspicuous on ornamentals and potatoes at Ottawa, Ont., and occurred in Colchester, Cumberland, and Pictou counties in Nova Scotia. *Pomphoepa sayi* (Lec.) fed on apple blossoms in some orchards in the vicinity of Quebec City, Que., and *Epicauta pennsylvanica* (Deg.), though present in many potato fields in Prince Edward Island, caused only minor damage.

**CUTWORMS.**—Cutworms were more abundant than for several years in the interior of British Columbia. Garden and truck crops in general were attacked. Losses were high in asparagus plantings in the Kamloops area. As many as three successive seedlings of small gardens were destroyed in the Summerland district. *Mamestra configurata* Wlk. was reported in small infestations at Soda Creek and near Barriere in the North Thompson Valley.

The red-backed cutworm caused relatively severe crop losses, chiefly to oats and barley, in Alberta for the first time in several years. Damage was most general in west-central areas but extended to Athabasca in the north, to Edmonton and Cremona in the south, and to Provost in the east. In the Lacombe district, where infestation was probably most severe, the loss was estimated at 4 to 5 per cent, but many fields were completely destroyed. The pale western cutworm was not a major pest in Alberta in 1950 although light losses occurred in east-central areas and along the Alberta-Saskatchewan boundary in the south. Some damage occurred at Provost, which is well north of the normal range of this species. In Saskatchewan it was more widespread and caused more severe damage to grain crops than for several years. Infestations were most general and severe in those parts of central and west-central Saskatchewan bounded by Delisle, Feudal, Stranraer, Kindersley, Elrose, Lucky Lake, and Birsay. Within this area losses averaged about 15 per cent; complete destruction of individual fields was common. Elsewhere in west-central and central districts, west of the South Saskatchewan River, light larval infestations were general and slight thinning or patchiness occurred in scattered fields. Localized areas, of severe damage also occurred in the Colonsay and Davidson-Craik areas of central Saskatchewan, and in the Hazlet area of southwestern Saskatchewan.



North of Saskatoon damage was reported or observed in only one field. Infestations of the red-backed cutworm were almost non-existent throughout the parkbelt and forested agricultural areas of northern Saskatchewan. Slight damage occurred on the University farm at Saskatoon and in a few gardens in the area. Larvae of the army cutworm were neither observed nor reported during the spring, but the moths were unusually abundant throughout southern and parts of central and west-central Saskatchewan, and at Melita and Neepawa in Manitoba. Climbing cutworms were of little importance in Saskatchewan in 1950, and in Manitoba very little cutworm damage of any kind was reported.

The armyworm occurred in outbreak numbers on winter wheat and to a lesser extent on corn along the north shore of Lake Erie in the Leamington-St. Thomas area of Ontario. This is apparently the first record of appreciable first-generation damage in the Province. At Harrow a local outbreak of this species destroyed a field of reed canary grass. Several species, mainly the dark-sided cutworm, the black cutworm, and *Feltia* sp. were present in outbreak numbers in many areas of Ontario and continued to cause damage well into the month of July. Garden crops were severely injured, notably in southern and eastern areas of the Province. The fall armyworm caused light damage to late canning corn near Essex. In Quebec, too, cutworms caused appreciable damage, mainly to garden crops. The black army cutworm was prevalent, particularly in the Abitibi and Lake St. John districts, and in the St. Cesaire district up to 50 per cent of young tobacco plants had to be replaced in some areas. In New Brunswick, cutworm infestation was limited to isolated localities, beans being most frequently attacked; damage in Nova Scotia, particularly by the variegated cutworm, was the greatest in several years. The armyworm was not reported in Nova Scotia in 1950. In Prince Edward Island the red-backed cutworm caused serious damage to several thousand acres of grain in Queens and King counties; the variegated cutworm was abundant and injurious in vegetable gardens generally; and the fall armyworm was present in almost every garden in the Province, causing injury to corn in particular.

**EUROPEAN EARWIG.**—This insect was more troublesome in southwestern British Columbia than in any year since the 1933-34 outbreaks.

**GRASSHOPPERS.**—A definite increase in grasshopper abundance occurred in many districts of British Columbia. In the East Kootenays, concentrations of *Melanoplus mexicanus mexicanus* (Sauss.) were less evident, but the general infestation was at least as great as in 1949. There was a slight increase in numbers of *Camnula pellucida* (Scudd.), especially in the St. Mary's Prairie district. Increased numbers of grasshoppers in the southern Okanagan Valley, and large numbers of *Melanoplus bivittatus* (Say) in irrigated forage crops in the Nicola Control Zone, required control measures. A further increase in numbers of *C. pellucida* and *M. m. mexicanus* occurred in the Lac du Bois area, immediately northwest of Kamloops. Several species appeared in moderate to severe numbers on ranch lands at Pavillion. North-central areas, including the Cariboo, the Chilcotin, and districts for many miles west of Prince George, supported moderate to large populations of *M. bivittatus*. Grasshoppers were reported from the Peace River area and, on the basis of a survey made on the Alberta side of this area, *M. bivittatus* and *M. bruneri* Scudd. were probably the main pest species.

The hatching of grasshoppers was later than usual in Alberta; the peak was not reached until mid-June, and damage was not so serious as expected. Most of the damage occurred in the MacLeod-Monarch-Claresholm area, in the vicinity of Drumheller, south to Gleichen, and intermittently along the eastern border from Provost to Schuler. There was late-summer damage to cover crops and to winter wheat. Late-summer populations were as numerous and as extensive as in the previous year. Particularly noticeable was an increase in the numbers of *C. Pellucida* in nearly all agricultural areas. This was the principal species in the northern parts of the grasshopper area, *M. bivittatus* being predominant in the southern parts. *M. m. mexicanus* and *M. packardii* Scudd. were of relatively little importance except for a few localized infestations, mainly in the eastern parts of the Province. Some isolated infestations

of *C. pellucida*, *M. bivittatus*, and *M. bruneri* were found in the Peace River region. Egg deposition as indicated by the fall survey was not so heavy as had been expected. The late development of the grasshoppers and outbreaks of *Empusa grylli* Fres. were partly responsible for this decrease.

For the third successive year grasshoppers were a serious hazard to crop production in Saskatchewan. As in 1949, some threat of grasshopper damage was present throughout two-thirds of the agricultural area of the Province, involving an area of about 65,000 square miles. The location and extent of the infested areas changed little from 1949; the area extended eastward and northward slightly in 1950, and the intensity of the infestation was reduced to sub-economic levels in the southwest corner of the Province. On the north and east, the boundary of the outbreak area extended approximately through Macklin, North Battleford, Prince Albert, Cudworth, Watson, Cupar, and Estevan. In southern Saskatchewan, cultivated areas south of the Cypress Hills were free of grasshopper outbreaks. Very severe and severe infestations developed in somewhat less than one-fourth of the outbreak area, chiefly in a zone 30 to 50 miles wide extending from Francis west to Moose Jaw, north to Elbow and Saskatoon, and west to the Cactus Lake-Reward-Landis-Kerrobert district in west-central Saskatchewan. Infestations of moderate intensity developed in about one-half of the area, in the remainder only light and scattered infestations were present. The principal species involved in the outbreak were *C. pellucida* and *M. m. mexicanus*. Fungous disease organisms were a major control factor throughout the Province in 1950. New records of grasshoppers obtained during the season include the following: *Melanoplus angustipennis* (Dodge) and *Melanoplus kennicottii* Scudd. at Beaver Creek; the rare species *Opeia obscura* (Scudd.) and *Mermiria maculipennis maclungi* Rehn at Coronach; *Stethophyma gracile* (Scudd.) in slough grass at Lorlie and Saskatoon; *Stethophyma lineatum* (Scudd.) in an alkaline area on the river bank at Saskatoon, the first record in Saskatchewan; *Trimerotropis agrestis* McNeill at Beaver Creek in open sand dunes, also a first record for the Province; and *Cordillacris occipitalis cinerea* (Bruner) on the edges of sandy blowouts at Pike Lake.

Because of an exceptionally cold and backward spring and summer, grasshopper hatching was late and irregular in Manitoba; nymphs could still be found in August. The earliest hatch occurred on the heavier soils on the west side of the Red River Valley. In the flooded districts along the Red River, grasshopper eggs hatched after the waters receded. In the second prairie level the hatch was so late and irregular that little poison was used. Adult and egg surveys made during the fall revealed that late development had cut down egg deposition and only 4,191 square miles were economically infested with eggs, as compared with 10,727 in the fall of 1949. Outside of a small infested area in the southwest, a lightly infested area southeast of Brandon, and an extension of light infestation northwest to Sidney and Beaver, the egg infestation was confined to the Red River Valley, west to the Pembina Hills, and north to the Assiniboine. Although the infested area was reduced, the severity was high compared with 1949. *M. bivittatus* was the predominant species, with *C. pellucida* almost as plentiful and more widely and uniformly distributed than in 1949. *M. m. mexicanus* was confined primarily to the lighter soil areas and was less abundant.

Grasshopper damage was very light in southwestern Ontario and below average in most areas of the Province despite the very severe infestation of 1949. In eastern Ontario large populations were reported in the area from Peterborough County eastward to Lanark County, and an outbreak occurred in Renfrew County. The principal species were *M. femur-rubrum* Deg., *M. mexicanus atlanis* Rly. and *C. pellucida*.

*M. femur-rubrum*, *C. pellucida*, and *M. bivittatus* were rather abundant early in the season in many areas of Quebec; but they were scarce in southwestern districts, where they had been abundant in 1949. Average populations were reported in the lower St. Lawrence Valley. A light infestation in Carleton County was the only one reported in New Brunswick. Grasshoppers were scarce in Prince Edward Island except for a few local infestations in the southeastern part of the Province.

**JAPANESE BEETLE.**—Trapping in southern regions of Eastern Canada resulted in the capture of 224 beetles as compared with 178 and 169 in 1949 and 1948 respectively. Captures were made as follows: Halifax 5, Montreal 1, Toronto 104, Niagara 49, London 33, Windsor 52.

**JUNE BEETLES.**—*Polyphylla perversa* Csy., as in recent years, caused considerable damage to vegetable crops in gravelly soil areas and to loganberries, seedling cherries, and other perennials on Vancouver Island and in the lower Fraser Valley. In the interior of British Columbia, white grubs damaged potatoes at Kamloops, Vernon, and Lavington, and strawberry plants at Kamloops.

*Phyllophaga anxia* Lec. was reported in greater numbers than usual in Alberta. Potatoes and strawberry plants were commonly attacked at Edson, MacLeod, Medicine Hat, and Drumheller. Potato injury is common in northern areas when they are planted in newly broken brush land. In Saskatchewan *P. anxia* was reported from such northerly points as Kelvington, Nipawin, and Prince Albert, and potato damage was reported at Biggar in the central agricultural area of the Province.

White-grub damage was reduced throughout most of Eastern Canada in 1950, but beetle flights were very large, particularly in southern and eastern Ontario, where extensive white-grub damage is anticipated in 1951. Second-year larvae of *Phyllophaga rugosa* (Melsh.) were injurious to many crops in the Niagara Peninsula but decidedly declined from the peak of 1944. In southern areas of Ontario County second-year larval damage by *Phyllophaga fusca* (Froel.) was not nearly so severe as during 1941, 1944, and 1947. Infestation in north Durham County was also reduced as compared with 1944. In Quebec, light to severe second-year white-grub damage was reported from the Quebec district and the Eastern Townships. Moderate injury was caused to strawberry plants near Charlottetown, Prince Edward Island.

**PAINTED LADY.**—The noticeable scarcity of reports of this insect contrasts with its widespread abundance during 1949.

**STALK BORER.**—This insect caused severe damage to tomato plants in the l'Islet district and to corn in the Riviere du Loup area in Quebec.

**TARNISHED PLANT BUG.**—Populations were low and damage was negligible throughout the Dominion.

**WIREWORMS.**—Adults of the injurious European species *Agriotes lineatus* (L.) were taken in several localities during a survey on the intensively infested farm near Cobble Hill on Vancouver Island, B.C., where the species was discovered in 1949. Further economic infestations of the native species *Agriotes sparsus* Lec., and an infestation apparently of a species of *Hemicrepidius*, were encountered in the lower Fraser Valley. An interesting infestation of a false wireworm, *Eleodes* sp., occurred at Victoria in a field of fall rye sown on heavy soil. In the interior of British Columbia, reports of wireworm damage were less numerous than in 1949. An unidentified species was reported to have caused 70 per cent damage to corn in one field at Armstrong.

*Ctenicera aeripennis destructor* (Brown) caused widespread thinning of dry-land wheat in Alberta. Severe losses occurred in the Stirling-Formost-Medicine Hat-Taber area, and in the Monarch-Vulcan-Calgary area, where thinning amounted to 25 per cent or more. The Claresholm-Nobleford-Champion-Taber-Burdett-Bow Island area in the south was also severely affected. Other points from which damage was reported included Consort, Red Deer, Coronation, and Sibbald. Damage was widespread in the Peace River district but not so severe as in 1949. Severe thinning occurred in a few fields in the Lethbridge-Spring Coulee area, and light damage was caused on irrigated land about Taber and Barnwell.

*C. aeripennis destructor* was the chief wireworm species responsible for moderate to severe thinning of grain crops throughout the greater part of the agricultural area of Saskatchewan in 1950. The greatest loss occurred in the central portion of the Province, and was more



general and severe than for several years. In northeastern and east-central Saskatchewan, damage was serious in only a relatively few fields. As in recent years, wheat seeded on summer-fallow was most severely damaged, although serious thinning also occurred in many crops seeded on stubble. The severity of wireworm damage appeared to be attributable to delayed germination and growth, and to low moisture conditions in some districts. The crop stand in a majority of fields examined in a survey along a route through North Battleford, Swift Current, Weyburn, Regina, and Saskatoon was reduced at least 10 to 20 per cent, and in many fields at least 30 to 40 per cent, and was highly variable from field to field in all areas. By comparison with other years, the outstanding feature of the wireworm situation in 1950 was the unusually severe thinning on an extensive acreage of heavy clay soils in the Regina, Rose-town, and Leader-Cabri districts. This is the first year that serious damage occurred so generally in the clay soils. Damage to vegetables, especially potatoes, was severe throughout the prairie and adjacent parkland areas of the Province. *C. aeripennis destructor* caused very little loss in Manitoba chiefly because of the cool, wet season; but *Limonius pectoralis* Lec. caused considerable damage to wheat.

*Limonius* sp. caused severe crop damage in southwestern Ontario. Several fields of potatoes were ruined, tobacco and tomato transplants were severely damaged, and winter wheat was injured in the Chatham area and as far north as Orangeville. In eastern Ontario cereal crops were considerably damaged on the Central Experimental Farm at Ottawa, and at Edwards a 20-acre field of potatoes was infested by *Agriotes mancus* (Say). No reports of wireworm damage were received from Quebec. Light infestations were recorded in the Stanley and Southampton areas of New Brunswick.

#### FIELD CROP INSECTS

**ALFALFA CATERPILLARS.**—*Colias* spp. and *Diacrisia* spp. were again very scarce in Saskatchewan and Manitoba.

**APHIDS.**—Infestations of *Toxoptera graminum* (Rond.) were more widespread and caused more damage to grain crops in Saskatchewan in 1950 than during the outbreaks that occurred in 1930, 1948, and 1949. Reports of infestations and damage were received from numerous points throughout the northern half of the agricultural area of the Province; these included Kamsack and Preeceville in east-central, Dundurn and Tessier in central, Herschel and Wilkie in west-central, Maidstone, Waseca, and St. Walburg in northwestern, Ardale, Melfort, and Watson in north-central, and Tisdale and Carrot River in northeastern Saskatchewan. In addition, infestations occurred near Moosomin in the southeast, where severe damage occurred in 1949, and in the Leader area in the southwest. No reports were received from the south-central area. The most serious damage occurred in the Carrot River district in northeastern Saskatchewan, where about 3,500 acres of fall rye and winter wheat in an area of 121 sections of peaty soils were totally destroyed; and in the Maidstone-St. Walburg area in northwestern Saskatchewan, where over 1,000 acres of fall rye were destroyed. Elsewhere, fall rye, and very late seeded oats and barley suffered varying degrees of infestation and discoloration, but most of the grain was expected to survive. The greenbug also appeared in large numbers in southern Manitoba and threatened late-seeded grain crops, but no appreciable damage was caused. In the Swan River Valley, fall rye was severely attacked and about 300 acres destroyed. *Macrosiphum granarium* (Kby.) was much less prevalent than in 1949 in the interior of British Columbia, and was of minor importance in Alberta although some severe damage to fall rye was reported from the Peace River district. In Saskatchewan, however, heavy infestations occurred on the heads of wheat, oats, and barley throughout much the same area as that of the greenbug. *Aphis maidis* Fitch was generally prevalent on corn in southwestern Ontario and in scattered infestations in Kamouraska County, Quebec, but no appreciable damage was reported. Aphids, probably this species, occurred also on corn at Kamloops, B.C. Although less abundant than in 1949, aphids appeared in large numbers on alfalfa at Soda Creek, B.C. *Macrosiphum pisi* (Kltb.) was common in alfalfa in northern Saskatchewan. An unidentified species was prevalent on clover in southwestern Ontario.

**BARLEY JOINTWORM.**—This insect has been increasing in numbers in Prince Edward Island in recent years and in 1950 almost completely destroyed crops in some areas.

**CLOVER WEEVILS.**—The sweetclover weevil is now well established throughout the irrigated regions of Alberta. For a time it was feared that the insect might destroy all wild sweet clover throughout the Province, thereby creating a serious problem for apiarists. In 1950, however, under favourable moisture conditions, the crop almost completely recovered in the south, despite little apparent reduction in the weevil population. Extensive feeding in northern areas caused only minor damage. In Saskatchewan, weevils were again abundant in the Tisdale, Arbourfield, Aylsham, Codette, and Nipawin districts, but damage was not serious. Early-spring control measures reduced populations but they built up again in late summer. A late-season build-up occurred also in Manitoba but little commercial damage resulted. *Sitona tibialis* Hbst. was abundant in many alfalfa fields in northern Saskatchewan and caused minor damage in the White Fox and Torch River districts. In southwestern Ontario, *Tychius picirostris* (Fab.) caused severe reductions in the seed yield of alsike, white, and ladino clovers; *Hypera meles* F. and *Hypera nigrirostris* (F.) caused significant reduction in the seed yield of red, white, alsike, and ladino clovers; and *Tychius stephensi* Schonh. caused considerable seed injury to red clover at all points observed. *T. stephensi* was also reported on red clover in the Ottawa area.

**CORN EARWORM.**—In Western Canada, no crop infestations were recorded at Victoria, B.C.; a few infested ears of sweet corn were found in the Barnwell area of Alberta; no infestation was found in a survey through Saskatoon, Lumsden, Cravan, Regina, and Moose Jaw in Saskatchewan; and in Manitoba the insect was reported to be very scarce. Throughout Eastern Canada infestations were light and developed too late in the season to cause appreciable injury, although local damage was recorded at Tecumseh, Ont., and on a farm in the Grand Lake area of New Brunswick.

**EUROPEAN CORN BORER.**—Larvae were found in six localities in the Estevan, Roche Percee, and south Carievale areas of southeastern Saskatchewan, where the borer was recorded in 1949 for the first time in the Province. In the area of Manitoba bounded by Rosenfeld, Winkler, Haskett, and Gretna, larvae were found in every field examined, infestation ranging from 3 to 5 per cent. At the Morden Experimental Station, stalk infestation of sweet corn was close to 50 per cent. A few specimens were found at Brandon. Distribution was more general than in 1949, when the insect was first recorded in the Province. The general infestation throughout Eastern Canada was lighter than in 1949. In Ontario, some sweet corn was severely damaged in Essex and Kent counties, but reduced populations were evident in late canning and husking corn crops, and in sweet peppers. The only large populations reported in Quebec were in the Chateauguay area. Very little damage occurred in New Brunswick, and little change was reported in Nova Scotia, where sweet corn was the main crop affected.

**HESSIAN FLY.**—In Tessier, Star City, Pense, and Lajord in Saskatchewan, damage was less than in 1949. It was not observed in Manitoba, but in southwestern Ontario it occurred almost in outbreak form for the first time in about 25 years. Infestation, ranging from 1 to 50 per cent, was widespread, but severe damage occurred in very few fields. A heavy local infestation was reported in Frontenac County.

**OAT NEMATODE.**—*Heterodera avenae* Lind., Rostrup, and Ravn., present in Ontario between Peterborough and Waterloo, continued to cause crop losses of importance in some areas.

**PLANT BUGS.**—*Lygus* spp. were present in small numbers in alfalfa seed fields of southern Alberta. Populations in northern Saskatchewan were slightly greater than in 1949, but were considerably below the period from 1946 to 1948. Appreciable yield increases resulted where control measures were practised. Populations in the alfalfa seed areas of Manitoba averaged less than one per net sweep. *Adelphocoris superbus* (Uhl.) was present in old alfalfa fields in Alberta but was of little importance. *Adelphocoris lineolatus* (Goeze) appeared in small numbers in alfalfa fields in the Hudson Bay, Arbourfield, Petaigan, Pas Trail, and White Fox districts of Saskatchewan. A few specimens observed in the Hudson Bay district in 1947 constitute the

only previous record in alfalfa fields in this part of the Province. The species was fairly numerous on alfalfa at Libau and Benito but was less prevalent in other areas of Manitoba. *Adelphocoris rapidus* (Say) occurred only in small numbers on alfalfa in Saskatchewan and Manitoba, but caused appreciable damage in the former province. *Plagiognathus obscurus* Uhl. was very numerous on alfalfa at Vernon, B.C., and species of the same genus occurred in small numbers throughout northern Saskatchewan, notably in the Petaigan and Ravendale districts. *Lopidea* sp., prob. *dakota* Knight, occurred in large numbers in an alfalfa field surrounded by a caragana hedge in Saskatchewan, and *Chlamydatus* spp. were found in small numbers on alfalfa north of Hudson Bay. *Melanotrichus flavosparsus* Sahl., always common on weeds, was reported from Beechy, Ruthilda, and Colonsay, Sask., where it was said to be attacking wheat.

**SAY STINK BUG.**—Some increase in numbers was noted early in the season in Alberta, but the insect has not caused any appreciable damage to grain since 1943.

**SUNFLOWER INSECTS.**—Only one specimen of the sunflower moth was found in Manitoba in 1950, but *Phalonia hospes* Wlshm. occurred in immense numbers. In the Altona, Morden, Carman, and Macgregor areas, damage averaged 5.4 per cent as compared with 3.5 per cent in 1949, and with 1.7 per cent in 1948 excluding the Macgregor area. *Zygogramma exclamationis* (F.) occurred in non-economic numbers. *Eucosma* sp., prob. *pulveratana* Wlshm., a new stalk-boring pest of sunflowers, occurred in small numbers. An undetermined species of trypetid infested 74.4 per cent of sunflower stalks in the Altona-Morden-Carman area as compared with 54.8 per cent in 1948.

**TOBACCO INSECTS.**—The green peach aphid was again the most important pest of both burley and flue-cured tobaccos in southwestern Ontario, the most severe infestations occurring along the shore of Lake Erie. Flea beetles caused some early-season damage; the tomato hornworm was scarce in both Ontario and Quebec; and although adults of the tobacco budworm were collected no larvae were found.

**WHEAT STEM SAWFLY.**—There was little change in the total area infested in Alberta, but the severity of infestation was reduced, where resistant varieties of wheat were grown. The most severe infestation since 1944 occurred in some fields near Nobleford and Barons. Little change from 1949 was reported in Saskatchewan, where severe infestations occurred over a large part of the southeastern area, in the Dundurn-Kenaston area of central, and in the Rosetown-Richlea area of west-central Saskatchewan. Infestations were heavy in the remainder of west-central Saskatchewan and extended in a narrow band through the Outlook, Elbow, Mortlach, and Assiniboia districts. Light infestations occurred in the remainder of the area usually infested. The European wheat stem sawfly was present throughout southwestern Ontario but in only a few instances did stem cutting approach 25 per cent.

#### VEGETABLE INSECTS

**APHIDS.**—The cabbage aphid was unusually abundant on cabbage in southwestern areas of British Columbia. Turnips were irregularly attacked in this area and in the Kamloops district by aphids believed to be of this species. In Ontario, aphid damage to cabbage was below average in eastern areas; and the turnip aphid, which caused a failure of the turnip crop in the Province in 1949, was of little importance. It was also a minor pest in Quebec and Nova Scotia. The melon aphid was numerous on cucumbers and melons throughout Ontario but built up to injurious proportions only in southwestern areas. The pea aphid was practically absent in the lower Fraser Valley, B.C., and of minor importance in Alberta. Control measures were necessary in many areas of Ontario and Quebec and much damage was caused to canning peas. Populations were below the 1949 levels in Nova Scotia, and in Prince Edward Island extensive damage occurred only in localized areas. Aphids attacking potato were generally prevalent throughout Eastern Canada, but only in Prince Edward Island were they reported in greater than average abundance. Some damage to tomatoes was reported in Ontario. The sugar-beet root aphid was again a serious pest of sugar beets in Alberta. The most severely



infested fields were in the Picture Butte and Magrath districts. Unidentified species of aphids seriously damaged peppers and were numerous on sugar beets in southwestern Ontario. Celery was damaged at Bradford, Ontario, and Punnichy, Saskatchewan.

*ASPARAGUS BEETLES*.—The spotted asparagus beetle extended its distribution in Manitoba, having been taken at Morden for the first time.

*CABBAGE SEEDPOD WEEVIL*.—This insect was somewhat less prevalent than in 1949 in southwestern British Columbia, but destroyed over half of the seed of cabbage in Saanich where not controlled.

*CABBAGEWORMS*.—The imported cabbageworm was much less abundant than usual in Western Canada, chiefly because of a lack of southern migrants. In Eastern Canada, too, damage was well below average. Some severe damage was caused early in the season in Ontario, but a threatened outbreak was controlled by larval disease, and damage to late cabbage and cauliflower was the lightest in four years. The diamondback moth was reported in Manitoba, Ontario, and Quebec, where it caused relatively slight damage. The cabbage looper, present in outbreak numbers in Manitoba in 1949, was not reported in 1950. In Ontario and New Brunswick, light damage was reported. The percentages of cabbageworm larvae on early cabbage in plots at Ottawa in July were: imported cabbageworm, 83; diamondback moth, 14; cabbage looper, 3. The percentages on late cabbage from mid-July to late October were: imported cabbageworm, 50; diamondback moth, 47; cabbage looper, 3.

*CARROT RUST FLY*.—Reported at Salmon Arm in 1948 for the first time in the interior of British Columbia, and at Nelson in 1949, the carrot rust fly was recorded in 1950 at Tappen and other areas in the northern Okanagan Valley. On the lower mainland and Vancouver Island, the first generation was late and unimportant, but the second generation caused severe damage to the main carrot crop. Celery and parsnips were scarcely infested on the mainland but the latter were severely damaged at Saanich. Irregular damage of varying intensity occurred throughout Eastern Canada.

*COLORADO POTATO BEETLE*.—Infestations were lighter than usual in infested areas of the interior of British Columbia, but one new infestation was reported from Bannington, west of Nelson. The insect was present throughout the area south of the North Saskatchewan River in Alberta, no infestations being reported north of the Camrose area. In Saskatchewan, insignificant numbers occurred in the Regina, Lumsden, Moose Jaw, and Saskatoon districts, and in Manitoba numbers were reduced from those of 1949; one adult, the first in six years, was taken at The Pas. Populations in eastern Ontario were at the lowest ebb in memory and were the lightest in years eastward to New Brunswick. The insect was fairly numerous in town gardens in Nova Scotia but scarce in Prince Edward Island.

*CORN ROOT WEBWORM*.—Larval damage to carrots was observed for the first time at Brandon, Man.

*FLEA BEETLES*.—The potato flea beetle was present at Estevan, Sask., but no damage was reported. Severe damage occurred in some gardens in Manitoba, where populations were comparable to those of 1949. Injury to potatoes and tomatoes was about average in most of Eastern Canada. The western potato flea beetle was present in the south-central interior of British Columbia in its usual numbers, but was moderately abundant at Soda Creek. Also, in the interior of British Columbia severe injury was caused to potatoes by the tuber flea beetle where it was not controlled. Its range has not extended beyond Clinton to the northwest, but a few specimens were found at Grand Forks, the first record east of Rock Creek. The population was greatly reduced on Vancouver Island and the lower mainland by severe winter conditions, but enough were left to cause severe infestations where not controlled. *Phyllotreta albionica* (Lec.) was almost entirely absent on the lower mainland and well below average in southern areas of Vancouver Island. Some early-season damage to cruciferous crops by *Phyllotreta* sp. was reported in Saskatchewan; *Phyllotreta vittata* (F.) was more abundant than in 1949 in

Manitoba and very prevalent on crucifers in Ontario. The hop flea beetle was scarce in British Columbia but more prevalent than in 1949 in Manitoba. *Chaetocnema* sp., near *ectypa* Horn, reported in British Columbia in 1949 for the first time, again caused considerable damage to sweet and silage corn.

**LEAFHOPPERS.**—The potato leafhopper was scarce in Manitoba and Prince Edward Island, more abundant than usual in Ontario and New Brunswick, and present in average numbers in Quebec and Nova Scotia. Populations of the six-spotted leafhopper were low, as was the incidence of yellows in asters and carrots in Saskatchewan and Manitoba. Abundance and injury to carrots were appreciable and comparable to 1949 in Nova Scotia.

**NEMATODES.**—The sugar-beet nematode, *Heterodera schachtii* (Schmidt), continued to be an important pest of sugar beets in the Blackwell area of Ontario, and minor spread was reported. Another small infestation was reported in 1949 from near Jeannette's Creek, Ont. Surveys for the potato-rot nematode, *Ditylenchus destructor* Thorne, in Prince Edward Island, revealed new areas of infestation, but the findings indicate that new infestations are revealed as new areas are cropped with potatoes and do not necessarily signify a spread of infestations.

**ONION MAGGOTS.**—Populations of the onion maggot were greatly reduced in British Columbia by control measures, but infestation was severe in neglected plantings. Severe damage was reported from Loughheed and Sedgewick in Alberta, from 18 points between Cumberland House in the north and Gerald in the southeast in Saskatchewan, and from The Pas in Manitoba. Damage was reported to be either severe or greater than usual throughout Eastern Canada except on Prince Edward Island, where the insect was reported to be not numerous. Larvae of the lesser bulb fly were present in large numbers on seed onions at Grand Forks in British Columbia.

**ONION THRIPS.**—Attacks were widespread in the interior of British Columbia, being severe in the Kelowna district and very evident at Kamloops and Grand Forks. Infestation and damage were severe in many areas of Ontario, where greenhouse cucumbers as well as onions were attacked.

**PEA MOTH.**—Garden peas were almost entirely free from infestation by the pea moth in southwestern British Columbia, but severe infestations occurred in many areas of Nova Scotia and Prince Edward Island.

**RED TURNIP BEETLE.**—No infestations were observed in southern Alberta in 1950 although the beetle was prevalent in 1949. In northern areas of the Province infestation was above average but damage was moderate. In Saskatchewan, damage was generally below that of 1949.

**ROOT MAGGOTS AFFECTING CRUCIFERAE.**—Root Maggots as in recent years caused considerable loss of stem crucifers on the lower mainland of British Columbia, control measures being inadequate. Damage in plant beds on Vancouver Island was severe but less than in 1949 in the early crop. Aerial infestation of brussels sprouts by the cabbage maggot was almost absent in 1950. Damage to turnips, though considerable on the mainland and severe until midsummer on Vancouver Island, was negligible in the latter area in autumn, in sharp contrast with 1949. *Hylemya crucifera* Huck. was present in moderate to severe numbers on turnip and to a lesser degree on cabbage and cauliflower in Saskatchewan, notably at Saskatoon, Moose Jaw, Regina, and Craven; cabbage was attacked also at Dysart and White Fox. *Hylemya planipalpis* (Stein.) infested radish at Saskatoon and White Fox, Sask., and was less abundant than in 1949 in Manitoba. *H. crucifera* occurred in severe infestations on turnip and to a lesser degree on cabbage at Dauphin, Man., and caused severe damage to turnips at Bissett, 100 miles northeast of Winnipeg. Root maggots, chiefly the cabbage maggot, were again abundant on early cabbage and cauliflower in eastern Ontario, and turnips were severely injured in late summer and autumn. Damage to turnips was apparently moderate in southwestern Ontario. The percentages of species of maggots on cabbage during the season in two fields at City View,

Ont., and Aylmer, Que., were: *Hylemya brassicae* (Bouche), 90; *H. cilicrura* (Rond.) and *H. floralis* (Fall.), 10. It was not possible to differentiate larvae of the latter two species. Percentages in turnip fields were:— City View: *H. brassicae*, 99; *H. cilicrura* and *H. floralis* 1; Billings Bridge: *H. brassicae*, 56; *H. cilicrura* and *H. floralis*, 44. *H. brassicae* was very destructive to crucifers generally throughout Quebec and eastward through the Maritime Provinces; in Prince Edward Island up to 40 per cent of the cabbage in many gardens were killed after coming into head. *H. floralis* was reported to be scarce in New Brunswick.

**SEED CORN MAGGOT.**—The sprouting seeds of beans and peas were frequently severely damaged in southwestern British Columbia. Populations were low in Manitoba. In Ontario damage to beans, corn, turnip, and vine, and other crops was severe, many fields of corn and beans being destroyed in southwestern districts. Infestation was general in Quebec and the Maritime Provinces. In New Brunswick, cucumber, corn, and bean seedlings were severely damaged and larvae were numerous on cabbage and turnip. Potato sets were damaged in about 25 per cent of the fields in Prince Edward Island, and in some cases fields had to be replanted.

**SLUGS.**—Damage was negligible in British Columbia but above average in Ontario, where rains were frequent during the summer.

**SPINACH LEAF MINER.**—Commercial spinach in the Cloverdale, B.C., area was infested, and in southwestern Ontario beets, spinach, and swiss chard were attacked. Infestation was severe in some cases.

**SPRINGTAILS.**—An unusual infestation of *Achorutes nivicolus* Fitch was observed at Leitrim, Ont., near Ottawa, on March 28. The snow was grey with the insects for a considerable area around a farmhouse and the infestation extended over 25 to 30 acres. The house itself was overrun both inside and out.

**SQUASH VINE BORER.**—This insect, now generally distributed in southwestern Ontario, caused severe losses but was less numerous than in 1949.

**STALK BORER.**—The first records of injury of economic importance in Manitoba were received from Goodlands, where rhubarb and potato were injured, and from Carman, where potato was attacked.

**TOMATO HORNWORM.**—Minor damage was caused to tomato foliage and fruit at Grand Forks, B.C. Populations were below average throughout Ontario, but larvae were reported to be abundant on tomatoes and tobacco at St. Jean, Que.

## FRUIT INSECTS

**APHIDS.**—Apple aphid infestations were again of considerable economic importance throughout the fruit-growing areas of the Dominion. *Aphis pomi* Deg. was the most significant species in most areas. It created a major control problem in British Columbia, particularly from Penticton north to Vernon in the Okanagan Valley. It was abundant in Ontario, but in southern areas along Lake Erie the infestation declined before much damage was done. Considerable injury occurred in Quebec. It was more prevalent in New Brunswick than in 1949, and extra sprays were necessary in some areas. A rapid early-summer build-up in Nova Scotia was checked by predators and dry weather and little damage resulted. *Anuraphis roseus* Baker was more abundant than in 1949 in central Ontario but less abundant in southwestern areas of the Province. In Nova Scotia it was more injurious than in 1949. *Eriosoma lanigerum* (Hausm.) was a much less serious pest than in 1949 in British Columbia, was of little importance in Ontario, and was at the lowest ebb in several years in Nova Scotia. *Rhopalosiphum prunifoliae* (Fitch) also was below average importance in Nova Scotia. The black cherry aphid caused little damage in British Columbia, and little change was noted in Ontario with the exception of the Niagara area, where it was more plentiful than for many years. The currant



aphid was more injurious than in 1949 in Saskatchewan, notably at Prince Albert, Moosomin, and Saskatoon. It was reported to be abundant also in Manitoba and Prince Edward Island, but damage was not serious. The mealy plum aphid showed little change in British Columbia and Manitoba, but was more abundant than in 1949 in Ontario, where many orchards were severely infested.

**APPLE AND THORN SKELETONIZER.**—This insect continued to be the most serious pest of tree fruits, particularly apples, in unsprayed orchards in southwestern British Columbia.

**APPLE MEALYBUG.**—Distribution was general in New Brunswick and Nova Scotia but damage was not important.

**APPLE AND BLUEBERRY MAGGOT.**—Heavy infestations were observed on hawthorn at Morden, Man. An increase in the number of infested apple orchards and in the severity of infestation was reported from Norfolk County and from other parts of Ontario except the Niagara and Oakville districts and the extreme southwestern area. Severe infestations occurred on apple in the Quebec, Neuville, St. Augustin, Champigny, St. Nicholas, St. Roch des Aulnaies, Sherrington, and Ville La Salle districts of Quebec, and a continued northwesterly spread was reported. An increase in the number of orchards infested and in the intensity of infestation occurred in New Brunswick and Nova Scotia, and severe damage was reported in Prince Edward Island. Infestation of blueberries has increased for two successive years in New Brunswick, the maggot being particularly prevalent in northern and eastern districts, and numerous even in areas where control measures had been taken. In Nova Scotia, infestation was severe in some areas and light in others.

**BLUEBERRY THRIPS.**—The species *Frankliniella vaccinii* Morgan was very prevalent over large areas of blueberry plantings in Charlotte County, N.B. Infestation exceeded 40 per cent in some instances, fruit failing to develop on such plants.

**BUFFALO TREEHOPPER.**—Severe infestations occurred in a few nurseries in the vicinity of Ste. Anne de la Pocatiere, Que., and young apple trees were attacked throughout the Province.

**CASEBEARERS.**—Species associated with fruit trees have been generally scarce, but in the Oakville, Ont., area heavy infestations built up in some apple orchards where calcium arsenate had been substituted for lead arsenate in early sprays.

**CHERRY FRUIT FLIES.**—*Rhagoletis cingulata* (Loew) was more numerous in southwestern British Columbia than for several years and for the first time was of major significance on sweet cherries. It was very numerous also in Prince Edward Island. *Rhagoletis fausta* (O.S.) occurred on pin cherry at Morden, Man.

**CODLING MOTH.**—Injury in the Okanagan and Kootenay valleys was the greatest since 1947 although the loss on the average was small. For the first time in several years, a partial third generation developed in the Osoyoos-Oliver area. Infestation in Ontario on both apple and pear was, in general, lower than in 1949, but damage was severe in neglected orchards in the Niagara district. In Quebec, too, damage was light except in neglected areas. Scattered light infestations were reported in New Brunswick; and in Nova Scotia the low level reached in 1949 continued in 1950, injury in commercial orchards averaging 5 stings and 3 deep injuries per 100 apples.

**CRANBERRY FRUITWORM.**—Cranberry bogs in New Brunswick were again heavily infested, as much as 80 per cent of the fruit being destroyed by the larvae. Average infestation was reported in Prince Edward Island.

**CURCULIONIDS.**—The plum curculio destroyed over 50 per cent of the Pembina plum crop at Morden, Man. Infestations on plum and peach were the heaviest in several years in Ontario; oviposition scars were numerous on apple but fall feeding was less than in 1949 in

southwestern areas. Infestations ranged from moderate to severe in Quebec, where the insect was rated the most serious pest of the fruit of apple, greatly exceeding the apple curculio which was a minor pest in 1950. The strawberry weevil was widely prevalent in Manitoba, economic damage being reported from Morden, Portage la Prairie, Neepawa, and Arden. It was prevalent throughout Eastern Canada, being particularly injurious in neglected strawberry patches where damage to buds ranged up to 60 per cent. The strawberry root weevil attacked strawberry, primula, polyanthus, and holly in southwestern British Columbia and was quite injurious where not adequately controlled. It was reported also from Morden, Man., where it was abundant on strawberry. *Barypeithes pellucidus* (Boh.) occurred on strawberry at Gormley, Ont.

**CURRENT FRUIT FLY.**—In Saskatchewan, abundance exceeded that of 1949, particularly in the west-central area, where missouri and black currants and gooseberries were extensively damaged, in some cases up to 100 per cent. In the Brandon area of Manitoba damage was greater than in either 1948 or 1949.

**EYE-SPOTTED BUD MOTH.**—Very little bud-moth damage occurred in the Okanagan and Kootenay valleys in British Columbia, although in 1949 cherry, apple, and prune were severely injured. Abundance, in general, was below the 1949 level in southwestern Ontario, but numbers were high in neglected orchards in the Niagara Peninsula. Severe bud damage to apple in southwestern Quebec and a further spread eastward to the Dunham-Frelighsburg area was reported. The bud-moth situation in New Brunswick has not shown any improvement in the last few years, due partly to ineffective control. Damage in the Annapolis Valley, N.S., was appreciable and comparable to that of 1949. Excellent natural control resulted in orchards where parasites and predators were not destroyed by sprays. Bud moth was prevalent in Prince Edward Island, particularly in the Charlottetown area.

**GREEN FRUITWORMS.**—An increase in numbers has occurred in recent years in Nova Scotia and shows no signs of abating. Injury in some orchards amounted to 4 or 5 per cent.

**IMPORTED CURRANTWORM.**—Light damage to currants was reported from Saskatoon, Sask., and from Brandon and Morden, Man. Infestation of currant and gooseberry was lighter than usual in Prince Edward Island.

**LEAFHOPPERS.**—Minor infestations of the white apple leafhopper were reported in the Montreal, Que., area and in Nova Scotia. The bramble leafhopper, reported for the first time during 1947 in the Victoria district of British Columbia, caused serious damage to loganberry and raspberry where not controlled. The potato leafhopper was abundant on apple at Morden, Man. The grape leafhopper was readily controlled in most areas in which it occurred.

**LEAF ROLLERS.**—The fruit tree leaf roller was reported to be of little consequence in Ontario and to have caused moderate damage in Quebec. The red-banded leaf roller declined slightly in the Niagara, Ont., area, causing injury in only a few apple orchards; elsewhere in the Province, slight to moderate increases were reported, but only a few orchards were severely infested. Most injury occurred late in the season. Damage in Quebec was not of economic importance. The ugliest caterpillar was abundant on choke cherry in Manitoba but was less prevalent than in 1949. This situation was general also in New Brunswick apple orchards, although severe infestations were reported from the Manguerville-Sheffield area. Leaf rollers were common in Nova Scotia but rarely caused serious damage. *Archips persicana* Fitch was the most generally occurring species. *Argyrotaenia mariana* (Fern.) increased slightly in numbers, and caused more fruit injury than any other species. *Archips rosaceana* (Harr.) apparently declined during the season, and *Pandemis limitata* (Rob.), though seldom numerous, was common in Kings County. *A. rosaceana* and *Pandemis canadana* Kft. occurred in considerable numbers in some orchards in New Brunswick.

**MITES.**—The European red mite occurred in greatly reduced abundance in British Columbia. This was mainly due, in the warmer regions, to improved control methods, but in the Salmon Arm-Kamloops area practically all of the winter eggs were destroyed by low temperatures. In Ontario, it was less abundant than in 1949 on apple, plum, and peach, causing injury in only a few orchards, but it appeared to be increasing on sour cherry in the Niagara area. Fairly heavy populations appeared late in the season in many apple-growing districts of Quebec, but it was generally less prevalent than in 1949. It occurred as an important pest on apple and plum in the lower St. Lawrence area of the Province, where it is not usually prevalent. In the Maritime area it caused little concern, being well controlled by predators in most districts where the latter were not destroyed by spraying. The two-spotted spider mite was injurious to raspberries in the Lulu Island area, where a survey indicated the species to be the only one of economic importance generally distributed in commercial raspberry, loganberry, and strawberry plantings. Severe infestations occurred from Penticton north to Salmon Arm, damage in the area being greater than at any other time on record. Moderate leaf damage occurred on raspberry at Saskatoon and Prince Albert in Saskatchewan. In Ontario, the species was plentiful on cover crops in many apple orchards in the Niagara Peninsula, but migration to apple trees was less than in 1949. It is becoming more generally distributed on peach in the Province but has caused severe injury in only a few cases. It is also reported to have been more prevalent on raspberry than in 1949. In Quebec, the species was more common than in 1949; and in Nova Scotia it caused appreciable damage to apple trees in the Annapolis Valley for the first time on record. The pear leaf blister mite, although of minor importance, appears to be increasing in British Columbia. A marked increase in injury to pear foliage was recorded in the Niagara area in Ontario, the most severe infestations occurring on nursery stock. Infestations of the clover mite occurred in a few orchards in the Okanagan and Kootenay valleys for the first time in many years, some apple trees being severely injured. It was more prevalent than in recent years in Ontario also, some damage being caused. The Pacific mite did not cause serious injury in British Columbia, but medium to severe infestations occurred in several orchards from Kelowna south to the International Boundary. In Manitoba it was less prevalent than in 1949 on raspberry, but severe infestations occurred on strawberry at Morden. *Tetranychus flavus* Ewing [= *Tetranychus willamettei* McG.], which was recorded at Summerland in 1949 for the first time in British Columbia, was found in many orchards from the International Boundary north to Kelowna. Severe infestations, almost exclusively on apple, were common in the Summerland and Kelowna areas. *Phyllocoptes* spp. were less common than in former years in the Okanagan and Kootenay valleys; and in Manitoba *Eriophyes* sp. was common on plum and cherry.

**ORIENTAL FRUIT MOTH.**—Infestation in the Niagara area and extreme southwestern Ontario continued the marked decline that started in 1949, and fruit injury averaged less than 3 per cent. Larval parasitism was at the highest level in several years.

**PEACH TREE BORERS.**—The peach tree borer has been decreasing in numbers since 1948 in British Columbia. Little change in abundance was recorded in Ontario. The lesser peach tree borer was more abundant in Essex County, Ont., than in 1949. One European-plum orchard had a severe infestation in the margins of extensive scald areas. The peach twig borer was practically absent in the Okanagan Valley, B.C., because of severe winter conditions that killed many peach and apricot trees. Two cases of shot-hole borer damage to peach were reported in Norfolk Co., Ont.

**PEAR PSYLLA.**—This insect was not a serious pest in British Columbia, because of improved control methods. In Ontario, severe infestations occurred only in neglected orchards. In Nova Scotia, a general abundance in pear orchards was reported but damage was comparatively light.

**PEAR SLUG.**—Damage to foliage was so severe in southwestern British Columbia that some cherry crops were reduced. Heavy infestations occurred in some young orchards and nurseries in the Niagara, Ont., area. Light infestations were reported from Quebec and Montmagny



districts in Quebec, and from Wolfville, N.S. In Prince Edward Island it was reported that almost every cherry tree was infested.

**RASPBERRY CANE BORERS.**—A significant flight of *Oberea affinis* Harr. occurred in eastern Ontario, and in New Brunswick a general infestation approached the status of an outbreak. *Oberea bimaculata* (Oliv.) was rather injurious in southwestern Quebec, after several years of minor importance, and was abundant also in the lower St. Lawrence area.

**ROSE CHAFERS.**—The rose chafer was more abundant than for several years in Essex County, Ont., where some damage to the fruit of peach and raspberry was reported. The green rose chafer damaged raspberries at Cut Knife, Winter, and Saskatoon in Saskatchewan.

**ROUND-HEADED APPLE TREE BORER.**—Important damage to young apple trees was reported from Quebec and eastern Ontario, and from the Douglas and Keswick Ridge areas in New Brunswick.

**SCALE INSECTS.**—The oystershell scale continued to be of little importance in commercial orchards in all fruit-growing areas of the Dominion with the exception of New Brunswick, where serious damage was reported in a few orchards in the St. John River Valley and little improvement over previous years was indicated. In British Columbia, the San Jose scale was at its lowest ebb in years, possibly because of the severe winter of 1949-50. In Ontario it was of economic importance only in neglected orchards in which it was moderately abundant southwest of London. An unprecedented outbreak of *Lecanium* spp. occurred on commercial pear and plum trees in southern areas of Vancouver Island. The large soft scale, *Pulvinaria* sp., which appeared in several apricot and peach orchards in British Columbia in 1949, was practically non-existent, and the European fruit scale remained at a low ebb.

**STRAWBERRY CROWN MOTH.**—This strawberry pest has been gradually increasing in numbers on Vancouver Island, B.C., and causing damage, particularly to 2-year-old plantings.

**STRAWBERRY LEAF ROLLER.**—Several severe infestations were reported in the Niagara district, and it was moderately abundant in Norfolk County in Ontario.

**TENT CATERPILLARS AND WEBWORMS.**—The eastern tent caterpillar was reported as being more common than usual on apple and choke cherry throughout all areas of Eastern Canada except Nova Scotia, where it was less prevalent than in recent years. In Saskatchewan, *Malacosoma* sp. severely defoliated saskatoon berry, plum, cherry, and rose at Pike Lake, Saskatoon, and in many parts of northern Saskatchewan. Some damage was caused to apple trees in Kings County, N.S., by the forest tent caterpillar. The spotless fall webworm, *Hyphantria textor*, Harr., was more abundant than in 1949 at Brandon, Man., but was apparently scarce elsewhere in the Dominion. *Malacosoma lutescens* (N. & D.) occurred in severe infestations in Manitoba but was less abundant than in 1949.

#### INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

**APHIDS.**—Many species of aphids were abundant on a wide variety of ornamentals, particularly in Manitoba and Ontario. The boxelder aphid was very abundant at Brandon, Man. Caragana hedges were severely defoliated in northern Alberta and at Saskatoon, Sask., presumably by *Macrosiphum caraganae* Cholod. Delphinium was damaged by *Kakimia wahinkae* Hottes in Saskatoon. Severe infestations of the wooly elm aphid appeared in Lethbridge, Alta., and it was abundant in Quebec. *Eriosoma lanigerum* (Hausm.) appeared to be even more abundant than *Eriosoma americanum* (Riley) on elm in northern Alberta. *Pemphigus* spp. severely infested poplar at Turin, Picture Butte, Iron Springs, and Monarch in Alberta. The poplar vagabond aphid was a pest of cottonwood windbreaks in Manitoba, and at Brandon caragana, pansies, sweet peas, and roses were severely attacked. Norway maple, elm, and copper beech were commonly attacked in Ontario, and in southwestern areas severe aphid infestations damaged a wide variety of ornamentals.

**BALSAM-FIR SAWFLY.**—This insect was the major pest of planted spruce south of Edmonton, Alta.

**BIRCH SKELETONIZER.**—Ornamental birch were severely skeletonized in Edmonton, Alta.

**A BOXELDER PSYLLID.**—A severe infestation of *Psylla negundinis* (Mally) occurred at Brandon, Man.

**BOXELDER TWIG BORER.**—This twig borer was more abundant than usual on boxelder at Portage la Prairie, Sandford, and Beausejour in Manitoba.

**COLUMBINE BORER.**—The columbine borer continued to be a very serious pest of columbine in Manitoba.

**EUROPEAN PINE SHOOT MOTH.**—Large populations again caused considerable injury to nursery stock and Mugho and other ornamental pines in Ontario in 1950.

**FALL CANKERWORM.**—Infestations occurred on boxelder at Dauphin, Souris, Brandon, and Winnipeg, Man. Grackles are believed to have checked the outbreak at Winnipeg.

**GARDEN SLUGS.**—Infestation of ornamentals was above average in Ontario and persisted throughout the summer.

**GLADIOLUS THRIPS.**—Infestations of this common pest were reported from Picture Butte, Calgary, and Red Deer, Alberta; Saskatoon, Sask.; Morden, Man.; and Ottawa, Ont.

**LEAFHOPPERS.**—*Erythroneura ziczac* Walsh severely damaged virginia creeper at Kamloops, B.C. Infestations were somewhat reduced in Alberta and at Saskatoon, Sask. *Empoasca* sp. severely infested all Chinese elm hedging in a nursery at Campbellford, Ont.

**LILAC BORER.**—Lilac was again infested in the Winnipeg area.

**LILAC LEAF MINER.**—Distribution was general in Quebec, infestation varying from light to severe, and lilac was severely infested throughout Prince Edward Island.

**MITES.**—Mites were abundant, as has been usual in recent years, on ornamentals throughout the south-central interior of British Columbia; on Vancouver Island and the lower mainland, *Rhizoglyphus echinopus* (F. & R.) and *Rhizoglyphus solani* caused economic damage to narcissus and lily bulbs. The cyclamen mite was a serious pest of cyclamen and strawberry at Brandon and Morden, Man., and the pacific mite was less abundant than in 1949 on rose and cotoneaster at Brandon. The maple bladder-gall mite continued to be a pest of soft maple in ornamental plantings in Ontario. Greenhouses in the Richmond Hill, Toronto, Brampton, Hamilton, and Simcoe areas had moderate to severe infestations of the cyclamen mite, and occasional infestations of the two-spotted spider mite. The latter species was injurious also to cucumbers grown under glass from March to July in southwestern Ontario.

**NARCISSUS BULB FLY.**—Infestation was considerably reduced from that of 1949, mainly by control measures, in southwestern areas of British Columbia.

**A NELUMBO BORER.**—In Mitchell's Bay, Lake St. Clair, Ont., *Pyrausta penitalis* (Grote) attacked one of the few stands of American lotus known in Canada. Approximately 60 per cent of the flower and leaf stems showed entry holes.

**PEAR SLUG.**—Cotoneaster was generally infested in Lethbridge, Alta.

**ROSE CURCULIO.**—The normal amount of damage was reported from Kipling, Scott, and Saskatoon, Sask., and from Manitoba.

**RHODODENDRON LACE BUG.**—Adult lace bugs, believed to be of this species, occurred in considerable numbers on rhododendron in a greenhouse at Centreville, N.S. This is a new record for the area.

**SCALE INSECTS.**—On Vancouver Island, the soft scale, which had been particularly injurious to holly and laurel, experienced a winter mortality of 95 per cent where the minimum temperature reached 60°F. An unprecedented outbreak of *Lecanium* spp. occurred on Japanese plum and maple in southern areas of Vancouver Island. The European elm scale, which is not common in the interior of British Columbia, occurred in moderate numbers at Kelowna. The oystershell scale was abundant on ornamental crab and mountain ash in the lower St. Lawrence River Valley in Quebec.

#### INSECTS AFFECTING MAN AND DOMESTIC ANIMALS

**BED BUG.**—The once common bed bug is becoming less numerous throughout the Dominion but considerable infestation still exists, particularly in the Prairie Provinces and other sparsely settled areas.

**BLACK FLIES.**—Severe black fly infestations were reported in the Kamloops area of British Columbia. There were no severe outbreaks in Saskatchewan in 1950. The livestock-infesting species, *Simulium arcticum* Mall., occurred in 3 small outbreaks, the first in the Albert-Macdowall district, the second at Saskatoon and Dundurn, and the third and most extensive covering 100 square miles at Baljennir. Each caused annoyance to livestock but no fatalities resulted. *Simulium venustum* Say was found in all streams examined between Saskatoon and LaRonge, 100 miles to the north, but caused annoyance to livestock and man only in the vicinity of LaRonge. It was found also in 15 out of 31 streams examined in the agricultural area of Saskatchewan but caused little annoyance except in the vicinity of a mile-long series of rapids on the Torch River, in the northeastern part of the Province. *Simulium vittatum* Zett. was more widely distributed than *S. venustum*, being found in 22 of the 31 streams examined, but it was not sufficiently abundant to become a pest. Two unidentified species of *Simulium* were found in most of the larger northern streams but were abundant only in the Torch River. *Cnephia invenusta* (Wlk.), a large species, was found in small numbers in areas adjacent to the South Saskatchewan River from Saskatoon to Fenton, and caused some annoyance to man. A small outbreak of *S. venustum* occurred along the Souris River in the vicinity of Melita, Man.; and in eastern Ontario *Simulium* spp. were much less numerous than in recent years.

**BLOW FLIES.**—There appeared to be an increase in myiasis in the Kamloops area of British Columbia in 1950, 5 human and 2 small animal cases having been reported. Five cases of infant infestation by *Wohlfahrtia* sp. were reported by doctors in northern Alberta.

**BOT FLIES.**—The general reduction in the horse population in Manitoba, and doubtless in other provinces, has resulted in a greatly decreased demand for horse bot remedies.

**DEER FLIES.**—*Chrysops excitans* Wlk. and *Chrysops mitis* O.S. were serious pests of livestock in northeast Saskatchewan.

**FLEAS.**—Reports of infestations of *Ctenocephalides* spp. were again rather infrequent.

**HORN FLY.**—A scarcity of this cattle pest was reported in Prince Edward Island.

**LICE.**—Head lice continue to be a problem, particularly in urban centres. Exclusions for this reason in Ottawa schools numbered in the hundreds in 1950. Infestations of *Linognathus piliferus* Burm. and *Trichodectes canis* DeG. were occasionally reported in Ontario and Quebec. Undetermined species of lice were reported on laboratory rats in Ottawa, Ont., and on guinea pigs in Winnipeg, Man.

**MITES.**—Cases of scabies were not uncommon among Ottawa school children in 1950. Mange in hogs was reported from northeast Saskatchewan.

**MOSQUITOES.**—Mosquitoes appeared to be more abundant than usual in the Kamloops area of British Columbia. Large numbers occurred in the vicinity of Edmonton, Alta., but most of them are believed to have been carried into the area from tamarack-swamp breeding grounds by strong northwest winds. They were not troublesome during the spring in Sas-



katchewan, but *Aedes spencerii* (Theo.) caused considerable annoyance to livestock and man at Fenton in late May, and *Aedes fitchii* (F. & Y.) occurred in smaller numbers in Waskesiu National Park in mid-June. Small numbers were troublesome in northeast Saskatchewan in late July and August. *Aedes vexans* (Meig.) and other species were abundant but well controlled at Winnipeg and Brandon, Man. Various species were very annoying for the longest period in many years in eastern Ontario and western Quebec. In Prince Edward Island, too, large populations were reported.

**TABANIDS.**—Horse flies and deer flies were the most serious of all livestock pests along the fringe of settlement in northeast Saskatchewan in July and August. The most abundant species of the former were *Tabanus frontalis* Wlk., *Tabanus haemaphorus* McD., *Tabanus lasiophthalmus* Macq., and *Tabanus affinis* Kby. In eastern Ontario tabanids were somewhat below average in abundance.

**TICKS.**—*Dermacentor andersoni* Stiles was more numerous than usual where collections were made at Rayleigh, B.C., and cases of paralysis in cattle and sheep were slightly above average in number. Large numbers of this species were collected in southwest Saskatchewan, and a great many harboured a highly virulent strain of the tularaemia organism. An infestation of a human by *Ornithodoros hermsi* Wheeler, Herms, and Meyer occurred at Okanagan Landing, B.C. Surveys for *Dermacentor albipictus* (Pack.) revealed a definite decrease in numbers of larvae in the Kamloops area of British Columbia. However, infestations on moose and deer during the spring season were as heavy as ever. A bull imported to Brandon, Man., from Montana was infested by this species. *Dermacentor variabilis* (Say) was abundant in the Wawanesa, Oak Lake, and Ninette districts of Manitoba.

**WASPS.**—Nests of several species of wasps were more numerous than usual, and a considerable nuisance about dwellings and garages, and under sidewalks in northern Alberta, and in Ottawa, Ont., and vicinity.

#### HOUSEHOLD INSECTS

**ANTS.**—Ants continued to be a major pest in dwellings, particularly in Eastern Canada. The black carpenter ant as in past years occurred commonly in Ontario and Quebec. The pharaoh ant was again frequently reported from Manitoba eastward to Prince Edward Island. Several extensive infestations of this species occurred in Ottawa, Ont., where four large office buildings were overrun, and in Montreal, Que., where an office building occupying two city blocks was generally infested.

**BOXELDER BUG.**—Residents of several dwellings in southwestern Ontario were annoyed by the presence of this insect during the winter, and it was more abundant than for several years in houses in northern Alberta.

**CARPET BEETLES.**—On the basis of reports, the black carpet beetle seemed to be the major fabric pest throughout Canada, apparently being more prevalent than clothes moths. *Anthrenus scrophulariae* (L.) occurred less frequently than the black carpet beetle in Eastern Canada and was not reported from western areas.

**CLOTHES MOTHS.**—Reports of infestations were fairly numerous but were outnumbered by those of carpet beetles. The casemaking clothes moth was the most prevalent species in Quebec and Prince Edward Island.

**CLOVER MITE.**—Many dwellings were invaded by this mite in northern Alberta. Infestations were reported also from Winnipeg and Alexander, Man., and Toronto, Ont.

**COCKROACHES.**—The German cockroach was occasionally reported in Western Canada but in Ontario and Quebec it was a common pest, reports being received at Ottawa from 9 urban centres. The oriental cockroach was reported from Winnipeg, Man., Seaforth, Ont., and unspecified centres in Quebec.

**CRICKETS.**—Reports of infestations were not numerous but included camel crickets at Ottawa and Trenton, Ont., and the house cricket in bakeries and institutions in Quebec.

**CUTWORM MOTHS.**—Large populations created a nuisance in dwellings in southern and west-central Saskatchewan, and in the vicinity of Ottawa and Kemptville, Ont.

**A HAIRY FUNGUS BEETLE.**—*Typhaea stercorea* L. occurred in large numbers on insulation in the walls of a dwelling at Newburg Junction, N.B.

**HOUSE CENTIPEDE.**—Specimens were received on four occasions at Ottawa, all being collected locally.

**HOUSE FLY.**—Populations were reported to be increasing in northern Alberta, in the Ottawa, Ont., area, and in Prince Edward Island. Light infestations were reported from Lethbridge, Alta., Saskatchewan, and Manitoba. DDT-resistant strains have apparently developed at Vegreville, Alta., and Ottawa, Ont.

**A SAP-FEEDING BEETLE.**—*Glischrochilus quadrisignatus* Say occurred in numbers in several dwellings near a fruit pectin plant at Cobourg, Ont.

**SILVERFISH.**—Infestations were reported, chiefly from large urban areas in British Columbia, Alberta, Ontario, and Quebec.

**SPRINGTAILS.**—An unusual infestation covering several acres at Leitrim, Ont., resulted in the invasion of a farmhouse by immense numbers of the insects, which were found even in the beds. Another unusual infestation occurred in a masonite-lined refrigerator in Ottawa. When control efforts failed, the back was removed from the machine and large numbers of the springtails were found quite active on the inner surface of the lining, close to the cooling unit.

**STRAWBERRY ROOT WEEVIL.**—Hibernating adults again occurred in many homes in Ontario, Quebec, and Nova Scotia.

**TERMITES.**—*Reticulitermes flavipes* (Kollar), which previously was known to occur in Ontario only at Toronto, was found in a small workshop in Windsor.

**WOOD BORERS.**—Powder-post beetles, *Lyctus* spp., continued to be an important pest in barns and dwellings in Eastern Canada. In some instances in Prince Edward Island, buildings had to be destroyed. A wood-boring sawfly, *Xiphidria mellipes* Harr., emerged in numbers from behind baseboards in a house in Windsor, Ont. *Trypopityus sericeus* Say damaged timbers in a dwelling at Como, Que. *Anoplodera nigrella* Say cut holes in gyproc, and *Monochamus* sp. in plaster, in dwellings in Montreal, Que.

#### STORED PRODUCTS INSECTS

**STORED GRAIN INSECTS.**—Canadian grain moved at normal rates in 1949; and as a result of this factor, as well as continuous inspection and the application of control measures when required, it was reasonably free from storage pests during 1950. Part of the United States grain that had been stored in Canadian elevators in the Bay Port area\* remained on hand, and it was found necessary to fumigate a major portion of it in order to prevent infestation of Canadian grain stored in the same facilities. The principal insects were the granary weevil, the flat grain beetle, the rusty grain beetle, and in a few cases the lesser grain borer.

The soft type of wheat grown in western Ontario and used in the manufacture of pastry flour was comparatively free from weevil infestation although some damage was caused. The 1950 crop has moved into consumption rather slowly, and an increase in storage problems

\* The "Bay Ports" originally referred to the grain storage ports on Georgian Bay, but the term is now used rather loosely to include all storage ports in the Great Lakes area except the Lake Head Ports on Lake Superior.

may be anticipated. Some instances were reported in December of wheat heating as a result of infestation by the saw-toothed grain beetle.

Feed grains stored on Ontario farms continued to show infestation by the granary weevil, the rice weevil, the sawtoothed grain beetle, the cadelle, the flat grain beetle, and the red flour beetle.

**MILL INSECTS.**—The flour beetles continue to be the most important insects found in flour mills in Ontario. In many of the smaller plants the Mediterranean flour moth is also of considerable importance. During September the Pure Food and Drug Divisions of the Department of National Health and Welfare undertook their first inspection of flour mill premises. It is the intention of the Department to place the inspection of such premises on a regular basis in order to raise the general standard of mill sanitation. In Alberta, the large flour beetle, *Tribolium destructor* Uytten., first recorded in 1945, now appears to be permanently established as a pest of flour, although it is nowhere abundant.

**SPIDER BEETLES.**—The spider beetle problem on the prairies has been substantially reduced by the widespread, continuous use of 5 per cent DDT in flour storage warehouses. In British Columbia, *Ptinus ocellus* Brown was a pest of major importance in warehouses as well as in the home. The degree of infestation in warehouses has shown a material decline through the increasing use of multiwall paper bags for stock feed. Some infestations have occurred in Eastern Canada, the hairy spider beetle, *Ptinus villiger* (Reit.) and another species, *Ptinus raptor* Sturm, being most frequently encountered.

**BEAN WEEVIL.**—Infestations were reported from Winkler, Man., Ottawa, Ont., and many localities in Quebec. In Nova Scotia it has become a rather serious pest since its appearance in Digby County in 1937, the first in the Province.

**CIGARETTE BEETLE.**—Extensive infestations occurred in two tobacco processing plants in Montreal, Que.; and at Chatham, Ont., a suite of upholstered furniture was infested.

**CONFUSED FLOUR BEETLE.**—Food materials in stores and in the home were frequently infested in Quebec.

**DERMESTIDS.**—The larder beetle was commonly reported as a pest of food materials in dwellings throughout the Dominion. *Trogoderma versicolor* (Creutz.), which has been common in some powdered milk plants, was not encountered in 1950.

**DRUG-STORE BEETLE.**—Infestations were reported from Winnipeg and Winkler, Man., and from Quebec, Que.

**INDIAN-MEAL MOTH.**—This insect continued to be commonly reported in homes and stores.

**A PEANUT BRUCHID.**—Specimens of *Pachymerus acaciae* Gyll. were found in an ocean-going vessel at Wallaceburg, Ont. Though a common pest in west Africa, the insect had not previously been intercepted in Canada.

**SAW-TOOTHED GRAIN BEETLE.**—This beetle was again one of the most commonly encountered stored-food insects in Eastern Canada.

**TOBACCO MOTH.**—The population of this insect was, in general, at a much lower level than in previous seasons in tobacco storage warehouses. The improved situation is largely due to the use of DDT.

**YELLOW MEALWORM.**—Reports of infestations in feed barns were fairly common in the Prairie Provinces.



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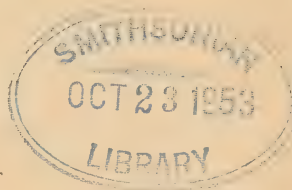
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# Entomological Society of Ontario



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## FINANCIAL STATEMENT

for

Year Ending October 31, 1951

*Receipts*

Dues .....	\$ 712.73
Subscriptions .....	407.56
Reprints .....	1124.42
Cuts .....	112.99
Back Nos., & Reports .....	217.80
Advertising .....	835.00
Miscellaneous (Gov't. Grant, refunds, bank exchange, etc.) .....	334.33
Cash on hand .....	3.29
	<u>\$3748.12</u>
Bank Balance 31 Oct., 1950 .....	\$1128.62
Less cheques outstanding 31 Oct., 1950 .....	876.85
	<u>251.77</u>
	<u><u>\$3999.89</u></u>

*Expenditures*

Annual Meeting .....	\$ 100.18
Printing The Can. Ent. ....	2202.42
Reprints .....	498.30
Postage, Express, etc. ....	43.54
Library .....	87.50
Miscellaneous (Stationary, refunds, bank exchange, etc.) .....	65.24
	<u>\$2997.18</u>
Less outstanding cheques 30 Oct., 1951 .....	91.00
	<u>\$2906.18</u>
Bank Balance 30 Oct., 1951 .....	1093.71
	<u><u>\$3999.89</u></u>

Audited and found correct,  
30 October, 1951

R. C. COOKE

C. J. PAYTON

REG. H. OZBURN,

Secretary-Treasurer.

A SURVEY OF INVESTIGATIONS ON THE DISEASES OF INSECTS<sup>1</sup>J. W. MACBAIN CAMERON<sup>2</sup>*Laboratory of Insect Pathology, Sault Ste. Marie, Ontario.*

## INTRODUCTION

The history of studies in insect pathology has been reviewed in detail several times, most recently by Steinhaus (1949). Therefore in this paper an attempt will be made to point out only the highlights of these past investigations, and to note some of the current problems and the methods being used in their study, with some suggestion of the future prospects of utilizing disease organisms as agents for insect control. Emphasis will be placed on viruses, fungi and bacteria, which are being studied at the Laboratory of Insect Pathology at the present time.

## FUNGUS AND BACTERIAL DISEASES

The first evidences of disease in insects appear to have been noted in the domesticated forms, notably bees and silkworms. It is over a hundred years since Bassi de Lodi demonstrated that muscardine disease of the silkworm was due to a fungus, which was described and named *Botrytis bassiana* by Balsamo, in honour of the discoverer. However, it was the investigations by Pasteur of the pebrine and flacherie of silkworms that first focussed the serious attention of scientists on diseases of insects.

About the same time mycologists were beginning to report the occurrence of fungi on insects other than the silkworm. In 1879 Metchnikoff, in Russia, made the first significant experiments in the use of microorganisms in insect control, when he was able to infect larvae of the beetle *Anisoplia austriaca* Hbst. with the fungus *Metarrhizium anisopliae* (Metch.). The results of this and later tests were so promising that in 1884 Krassiltschick established a laboratory for the purpose of producing spores of the fungus on a large scale. In reviewing the investigations on fungi, Metalnikov and Chorine (1928) state: "All these experiments very clearly demonstrate that the entomophytic fungi are terrible enemies against harmful insects, but unfortunately the entomophytic fungi require special conditions for their development, such as humidity, a favourable temperature, etc., not always found under natural conditions. That is the reason why, up to the present time, attempts to apply fungi on a big scale, as a remedy against noxious insects, have given contradictory results. Nevertheless we believe that the entomophytic fungi may play a very important part in the fight against insects, but it is necessary to find a very virulent fungus for each particular insect and to act at the season most favourable for its development." While it is true that fungi, as well as other pathogens, are important in insect control, most current investigations suggest that entomophytic fungi are not specific, as Metalnikov and Chorine thought, but rather that they have a variety of hosts, and that their virulence is at least partly dependent on physical factors.

Krassiltschick (cited in Metalnikov and Chorine, l.c.) also made the first attempts to utilize bacteria in controlling insects. He isolated two bacteria from *Melolontha vulgaris*, but was unable to maintain their virulence in culture. Injection into the blood usually caused infection, but no success was obtained by feeding.

Up until 1911 most of the attention was concentrated on fungi, with a few references to protozoa. Then d'Herelle isolated a bacterium, *Coccobacillus acridiorum*, from dead and dying locusts in Mexico. He reported positive results of infection *per os*, and his work was followed by a number of attempts varying in success from regular kill in four hours (Sergeant, 1916, cited in Metalnikov and Chorine) to such poor results that the method was recommended only as a

<sup>1</sup>Contribution No. 36, Division of Forest Biology, Science Service, Department of Agriculture, Ottawa, Canada.

<sup>2</sup>Officer-in-Charge.

supplement to chemical control (Lounsbury, 1913, cited in Metalnikov and Chorine). In general, the first great optimism gave way to discouragement regarding the possibilities for using bacteria in insect control, although here again much of the disappointment may be attributed to lack of attention to fundamentals. It is fairly certain that a number of different strains of *C. acridorum* were used, and in some cases against hosts now known to be resistant to this bacterium.

From 1910 on, a number of investigators were engaged in studies of insect diseases. Paillot (1922) investigated many fundamental problems in nearly all the major phases of insect pathology and after extensive work he was very pessimistic about the utilization of disease as a means of control. He was unable to obtain any bacterial infection by way of the digestive tract even under laboratory conditions, and did not believe that it would occur in nature. Metalnikov and his associates dealt especially with immunity principles in insects. They tested a large number of disease-causing organisms such as those of tuberculosis, leprosy, tetanus and diphtheria, and found that insects were highly resistant to them, though frequently very sensitive to such bacteria as *Bacillus subtilis* and *B. proteus*, which are of limited virulence to man. (In the light of present knowledge, this result would not be unexpected). They thought that insects could build up immunity more easily than other animals. Changes in the virulence of the bacteria in culture seemed to have a great effect on ability to produce epidemics; cultures taken from sick larvae were very potent, but in culture the effectiveness rapidly disappeared until finally they would cause death only when injected into the body cavity. They concluded that bacteria of insects are highly adapted to their hosts and need very particular conditions for their development. Creation of artificial epidemics requires a limited range of physical conditions and they recognized that lack of knowledge of many of these requirements would explain the contradictory results obtained in attempts at practical application of entomophytic microorganisms.

In the 1920's, the European corn borer was a pest of major importance both in Europe and in North America. A group was organized under the aegis of the International Livestock Exposition, Union Stock Yards, Chicago, to investigate means of controlling this insect. Most of the work was done in Central Europe, though some parts were carried out in other countries, including Russia. A series of reports was prepared under the editorship of Tage Ellinger, indicating that extremely promising results were obtained with both fungi and bacteria. For example, Husz (1928) reported that *Bacillus thuringiensis* under certain conditions is pathogenic to corn borer larvae. Under the conditions of the experiments, the larvae were killed in 36 hours when fed on foliage contaminated by the bacillus or its spores. Infection was found to be possible by placing the spores on any surface with which the larvae came in contact. The spores withstood temperatures up to 100° C. without reduction of virulence or viability, and the bacterium could be produced readily on plain meat agar without any loss in virulence. Husz concluded: "Considering all these facts, it may be possible to develop practical methods for applying *Bacillus thuringiensis* in the fight against the corn borer".

In summarizing the investigations of four years, Vouk (1931) stated that a number of new bacteria had been found whose pathogenicity for healthy corn borer larvae was clearly demonstrated. By artificial infection extensive mortality was caused among the field population. He concluded "...hardly any doubt remains that bacteria can be applied successfully in the fight against the corn borer. The scientific problem has been completely solved. The practical development of the method is now merely a question of technical and economic character, the significance of which should certainly not be underestimated." Unfortunately, this optimistic conclusion has not been borne out in the succeeding years.

The same series of investigations also included the use of fungi to control the corn borer. Toumanoff (1928) made serial sections of corn borer larvae infected with *Aspergillus flavus* and *Spicaria larinosa* to study the progress of fungus growth; in no case did he find infection through the intestinal tract. The fungi developed in the temperature range from 18° C. to 30° C. He did not believe that special humidity conditions were necessary, due to the occurrence of cuticular secretions which kept the larvae quite moist, though this is very different from the findings of Quinn (1951) using spores of several strains of *Beauveria*. Metalnikov and Toumanoff (1928) sectioned dead and sick larvae, and always found fungal growth in the body cavity, infection



having taken place through the skin, which they state is "the only method of infection known up to the present time". They concluded that "the *Pyrausta* larvae are very easily infected by parasitic fungi even in the absence of moisture. Infection may result from simple contact with the spores of the fungus".

Hergula (1931) claimed a 99 per cent reduction of corn borer population by dusting corn plants with a mixture of 1 part by volume of *Metarrhizium anisopliae* spores with 5 to 20 parts of starch. Climatic conditions at time of application had little influence on the effectiveness. Dusting should be carried out before or just after hatching of the eggs, as the infectivity of the mixture is lost seven days after application, due to weathering and the effect of solar radiation.

In summing up the general results from four season's investigations, Ellinger (1931) stated that in Hungary and Yugoslavia, under ordinary farming conditions, the extent of corn borer infestation had been reduced by 50 per cent by the use of disease organisms. In Germany, however, results were disappointing. He continued: "Such contradictory results are not surprising to those familiar with microbiology. Our knowledge of the pathogenic microbes used in the experiments is still so new and so limited that it really is more surprising that such difficulties have not arisen before. As a probable explanation it suffices to suggest the laboratory problems of detecting immediately a diminution in the virulence of the bacteria and the germinative faculty of the fungi". Experiments in Canada and the United States also have shown that fungi are certainly not the complete answer to the problem of controlling the corn borer.

#### VIRUS DISEASES

While the diseases caused by fungi and by bacteria were being recognized and studied, another group was being neglected because of lack of facilities. These are what are now known as the virus diseases. Investigation of viruses began towards the end of the last century, when it was discovered that mosaic disease of tobacco could be transmitted from diseased to healthy plants by means of bacteria-free filtrates of juice from the affected plants. About the same time it was demonstrated that foot-and-mouth disease of cattle was caused by the same type of agent, and shortly thereafter diseases caused by filterable agents were recognized in numerous plants, in man and other vertebrates, and in invertebrates. Glaser and Chapman (1913) demonstrated that the "wilt disease" of gypsy moth caterpillar and other insects also fell in this class. No active agent could be seen by any of the recognized techniques, and therefore they came to be known as filterable viruses, soon shortened to the term virus now commonly used.

Viruses fall into two classes, based on the type of inclusion bodies formed within the host cell. In the polyhedral diseases the inclusion bodies are crystal-like, while in the capsule type they are granules. Steinhaus (1949) recognizes two additional types, but other investigators do not agree, and at the present time there is no universally recognized system of nomenclature.

Much of the present knowledge of insect viruses is based on investigations of the disease generally known as "jaundice" in silk-worms. The history of this disease has been fully traced by Steinhaus (1949) and need not be repeated here. The advances in the knowledge of the field have been very rapid, especially in the past two decades, probably due in large part to the development of such instruments as the electron microscope and the ultracentrifuge. For instance, from the work of Bergold (1950, 1951) it is now recognized that the inclusion bodies are not the actual virus. Rather the virus is contained within the inclusion bodies, and amounts to less than five per cent of the total weight. The virus particles can be liberated from the inclusion bodies by treatment with weak alkali, and they are demonstrably the infectious agent of the disease. The polyhedra contain numerous virus particles, either singly or in bundles, whereas there is only a single particle within each capsule.

Studies of the chemical composition of both the virus and the occluding body have been made. Smith and Wyatt (1951) isolated desoxyribose nucleic acid from the purified virus of gypsy moth. They found that there is a wide range of nucleotide composition in the nucleic acids from different microorganisms. Wellington (1951) examined the purified virus and the

polyhedral protein of jaundice of *Bombyx mori* and the purified virus and the capsule protein of granulosis of *Cacoecia murinana*. She found the same 17 amino acids occurring in all four of these proteins, but was unable to do a quantitative analysis. However, she did test quantitatively for an eighteenth amino acid, tryptophane; she could not demonstrate it in the viruses, but found it to the extent of approximately 3 per cent in both capsular and polyhedral protein. Further quantitative tests are in progress, and their results may indicate other differences.

The virus particles of the silkworm jaundice are infectious at dilutions of  $10^{-11}$  gram of protein per larva. They are enclosed within a membrane and show indications of internal structure, and their reaction to such agents as glycerol, alcohol, ether, and freezing indicates that they have some properties characteristic of living microorganisms. Bergold (1950) has described the development of virus particles through a series of stages which he interprets as evidence that they are actual organisms. He compared (Bergold, 1951c) virus preparations from blood cells of silkworms with those isolated from polyhedral bodies from the same insect, and found similar rods, spherical developing stages, and tube-shaped virus membranes in both. Bird (1951) studied thin sections of the digestive cells of European spruce sawfly in the electron microscope. He found both small spherical particles and rods free within the nucleus as well as enclosed in the polyhedra, and concluded that the polyhedra arise as ultramicroscopic bodies, and that multiplication and development of the virus take place within these bodies as well as free in the cell.

The histopathology of polyhedral viruses has been studied by a number of investigators. In the Lepidoptera the tissues infected include the blood cells, the hypodermis, fat tissues and tracheal matrices. In some cases other tissues have been reported as infected, but not with any degree of regularity. In the Hymenoptera, only the spruce sawfly, *Diprion hercyniae* (Htg.) has been studied intensively; here infection occurs in and is confined to digestive cells of the mid-gut epithelium; this may be characteristic of infection in members of this order. In the capsule viruses, the infection seems to be limited largely to the fat body, and the granules usually become apparent first in the cytoplasm, in contrast with the polyhedral viruses which first show up in the nuclei.

#### RECENT DEVELOPMENTS IN UTILIZATION OF INSECT PATHOGENS

Insect diseases may be divided into two groups: Those that may be useful in controlling injurious species, and those that cause economic losses when useful or beneficial species become infected. Most of the fundamental studies carried on prior to 1940 were on diseases of the second group. A large number of attempts were made to utilize microorganisms in the control of injurious insects, probably the most ambitious being the program to control European corn borer already referred to. But many of these attempts, which started out with great promise, resulted in unsatisfactory control and were dropped. These disappointments resulted in a general feeling that the entire method was useless, and led to a lack of interest in the subject for many years. Probably a major factor in these early investigations was the rather general neglect of the fact that disease is merely one element of insect ecology, and must be considered as such. Biological control factors, both entomophagous and microbiological, are at work among all natural insect populations, and are probably more important than is generally believed in maintaining the balance of nature.

Within the past 15 years it has become increasingly apparent that the field of insect pathology required more intensive study than had been given it previously. A number of cases that were examined more or less carefully have already been mentioned. Steinhaus (1949) reviews these as well as others in more detail. The U.S. Department of Agriculture in 1939 began a program to study the milky disease of Japanese beetle caused by *Bacillus popilliae* and to produce the spores of this organism in quantity as a means of control. Results have been excellent, and in ten years nearly 150,000 pounds of spore dust were used in treating over 80,000 acres (White and McCabe, 1951). Additional quantities were produced and distributed by commercial concerns. Utilization of fungi has been less satisfactory, and as yet there is no case where consistently favourable re-



sults have been obtained. In this case lack of attention to fundamental details has been a contributing factor. For instance, MacLeod (unpublished data) has shown that some twenty or more described species in the genus *Beauveria* actually are strains of only two species, and that they differ greatly in their ability to cause disease. It will be a long-term program to put the study and use of fungi on a sound basis.

On the other hand, the use of viruses is steadily becoming more promising. Balch and Bird (1944) appear to have been the first to demonstrate that a polyhedral virus can be introduced into new areas, when they used an aqueous extract prepared from diseased European spruce sawfly larvae in New Brunswick to infect that insect in certain areas in Newfoundland. Prior to this introduction no diseased insects had been found in the latter province, but in the following years the virus became prevalent over considerable areas surrounding the points of treatment.

These developments stirred up new interest in the field, and in 1945 the University of California established a Laboratory of Insect Pathology at their College of Agriculture. In 1946 a program of investigation was set up at the Forest Insect Laboratory in Sault Ste. Marie, Ontario, and within a year it was apparent that special facilities would be required to carry on such a program adequately. As a result, plans were drawn for a new laboratory, construction of which was completed in 1950. It is completely equipped for carrying out fundamental studies on microorganisms, as well as for producing useful organisms in quantity when necessary. Investigations are going forward on the pathogenicity of, and mode of infection by bacteria, the classification and physiology of fungi, and the biochemistry, characterization, pathogenicity and histopathology of the viruses. A general survey is being made of the occurrence of diseases in forest insect populations by means of samples submitted by various forest insect laboratories. Field studies of pathogens affecting populations of the spruce budworm and the larch sawfly in northwestern Ontario are being carried out by staff of the Forest Insect Laboratory, in cooperation with the Laboratory of Insect Pathology.

In addition, field experiments are being carried out on the effectiveness of virus diseases in controlling sawflies. The work of Balch and Bird (1944) on European spruce sawfly in Newfoundland and New Brunswick has already been mentioned. In 1949, an infestation of this insect was found near Thessalon, Ontario. Extensive sampling indicated that no disease was present (Bird and Whalen, 1951) so in 1950 an experimental dissemination of virus was undertaken. Intensive sampling was carried on throughout 1951, and the results indicate that disease has become well-established and in the immediate vicinity of the point of application has caused extremely heavy mortality, while at the same time it has spread to unsprayed trees up to a half mile from the sprayed area.

In southwestern Ontario, the sawfly *Neodiprion sertifer* (Geoff.) is a serious pest in plantations of Scotch pine grown for Christmas trees. The same insect is a pest in Europe, where a virus disease infecting it was discovered. Dead European larvae were sent to the Sault Ste. Marie Laboratory in 1949, and the virus material was extracted, tested against the Canadian population and found to be highly virulent. Preliminary field tests carried out by Bird in 1950 indicated that this virus might be highly practical as a control. The program was extended in 1951, when the virus suspension was applied by means of a power-operated fog generator. Again results are incomplete as cocoon and egg surveys are still to be made. The indications are that this method of application is comparatively easy and highly effective, and that this particular disease can be readily established as a continuing control against the insect.

Steinhaus and Thompson (1949) used a polyhedral virus to control the alfalfa caterpillar, and found it quite effective. Steinhaus (1951) also used the bacterium *Bacillus thuringiensis* against the same insect with promising results. The bacterium did not give quite as great total reduction as did the virus, but it was effective much more quickly, most of the larvae dying within the first 48 hours. He speculates that it might be advisable to use the two diseases together, depending on the bacterium for initial rapid kill, and on the virus to hold the surviving population at a low level.



The examples just cited are some of those in which a reasonable degree of success has been attained. Many others could be mentioned where results have been disappointing. For instance, tests with spruce budworm, which is one of the major forest insect problems at the present time, indicate that presently known diseases are ineffective in controlling this insect (Bergold, 1951a). It is possible by artificial means to infect the larvae with massive doses of virus which will cause their death, but so far no means has been found to produce results similar to those obtained with the sawflies. Most of the natural populations appear to be normally infected by a capsule virus, and it appears that this immunizes them against infection by other virus diseases.

The recent outbreaks of tent caterpillars in Ontario provided an opportunity to carry out investigations on the diseases affecting this insect. A polyhedral virus was recovered from populations in a number of widely scattered localities in 1950 (Bergold and McGugan, 1951). Mass multiplication of the virus was attempted in 1951, but the results were not satisfactory due to the occurrence of a bacterial disease in the crowded insect population (Bergold, 1951b, Angus, 1951). Feeding tests with the virus suggested that there is an immunity problem to be investigated; this will require intensive investigation and clarification before control by means of an induced epidemic can be expected.

#### DISCUSSION OF VARIABILITY IN RESULTS

It may be useful to speculate on the apparent variability in efficiency of disease as a means of insect control. Possibly one of the biggest factors is that of the insect population involved. We as yet know very little about the interactions between host and disease. It has often been observed that an insect population is affected by disease, and the numbers greatly reduced, but in very few of these cases is it known what brought about the sudden apparent increase in virulence of the causal organism. Possibly it has been due to climatic factors — in the majority of cases this has been given as an explanation, especially where bacterial or fungus disease were involved — but it may equally well be, for instance, genetic factors. Possibly the disease organism has undergone a mutation that resulted in greatly increased virulence, but produced a strain unable to maintain itself after the first flare-up and consequently disappearing. Or perhaps it is the stress conditions, such as overcrowding and starvation, that occur in cases of outbreak that reduce the resistance of the population to the disease organism. Climatic factors undoubtedly do play a part, but whether directly on the microorganism, or indirectly by weakening the host so that it becomes more susceptible, is not known. The apparent specificity of the organism for its host in many cases is also a factor, and one which may account for some of the contradictory results that have been reported. Thus *Bacillus thuringiensis* referred to above is morphologically and culturally the same as *B. cereus*, but differs in that it is pathogenic for insects, while most strains of *B. cereus* are not (Steinhaus, 1951). It is probable that many of the conflicting results reported from the use of this bacterium have been due to the fact that different strains were used. Similarly the disappointing results from the use of *Coccobacillus acridiorum* were probably due to using non-pathogenic strains, or to attempting to use it against grasshoppers in general when actually it appears to be effective only against those of the genus *Schistocerca*.

#### SUMMARY

So we come to the conclusion that we must concentrate on the fundamentals for some time, and not worry too much about immediate application. True, opportunities to apply microbial control will probably present themselves frequently and advantage should be taken of them, but at the same time they should also be used as opportunities to learn more about the fundamental problems.

Possibly no better summary for this discussion can be found than the following quotation from Ellinger (1931): "The positive results, therefore, support the conviction that pathogenic bacteria and fungi" (and we can now include viruses as well) "may be used successfully in the

fight against noxious insects; the negative results warn that continued experimentation and painstaking research regarding the biological properties of the microorganisms are essential to prevent occasional disappointments in their practical application".

#### ACKNOWLEDGMENTS

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## CUTWORM CONTROL WITH ALDRIN, DIELDRIN AND HYMAN COMPOUND 269 IN BAITS

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Cutworms of various species are injurious to vegetable and field crops and flowers somewhere in Manitoba every year. For many years poisoned baits containing some form of arsenic have been recommended to control them. Some experimental work has been undertaken elsewhere recently, with sprays and dusts applied to the surface of the soil with some of the chlorinated hydrocarbons, but baits are still relied upon for the control of cutworms which feed above the surface of the soil.

For at least three decades until 1949, poisoned baits containing various forms of arsenic were used to control grasshopper outbreaks in Manitoba. During that year and since that time toxaphene, chlordane and now aldrin have replaced the arsenic with increasingly satisfactory results. In 1951 experiments were undertaken in the Department of Entomology at The University of Manitoba to learn if some of the newer chlorinated hydrocarbons are lethal to cutworms. Aldrin, dieldrin and a newer insecticide known as Hyman compound 269 were each fed in three concentrations in a bran-water bait to a mixed population largely composed of the red-backed cutworm, *Euxoa ochrogaster* (Guen.). Other species reared from the larvae collected were *Euxoa tessellata* (Harr.), *Chorizagrotis thanatologia* Dyar and *Feltia ducens* Wlk.

**MATERIALS.**—Partially grown cutworm larvae were collected from an infested field of peas near Altona, Manitoba, on May 26, 1951 after which they were brought to the University and fed daily on fresh alfalfa foliage while the supply was being used. Nine different baits and a check were fed to the different lots of cutworms. Each of the baits and the check consisted basically of 25 grams of bran and 25 cc. of water. To baits Nos. 1, 2 and 3 were added 0.15 gms., 0.30 gms. and 0.60 gms. of actual aldrin, respectively, sample No. 6992. Baits Nos. 4, 5 and 6 contained 0.15 gms., 0.30 gms. and 0.60 gms. of actual dieldrin, respectively, sample No. 6994. To the bran and water base of baits Nos. 7, 8 and 9, Hyman compound 269 was added at the rate



of 0.15 gms., 0.30 gms. and 0.60 gms., respectively, sample No. 7010. Each insecticide used was in the form of an emulsifiable concentrate. The bran-water mixture was fed to each group of cutworms.

All experimental lots of cutworms were placed in open, clean, circular, tin containers with straight sides, approximately  $10\frac{1}{4}$  inches in diameter and  $1\frac{1}{2}$  inches deep, from which they were unable to escape. All experiments were carried out in a room where the temperature ranged between  $66^{\circ}$  F. and  $73^{\circ}$  F. with a relative humidity varying from 36 per cent to 42 per cent. Poisoned bait from the same sample, which had been kept tightly covered, was fed in each of the four replicated experiments.

**METHODS.**—Twenty cutworm larvae approximately half grown were placed in each of the ten tins for each replicate. Fresh alfalfa foliage was given to each lot of cutworms before and daily during each experimental period. The designated amount of each insecticide was added to 25 cc. of water and the two shaken thoroughly and then poured over the 25 gms. of bran which in each case had been placed in a new one-half pint Atlas cardboard container. After the cover had been adjusted the mixture was shaken thoroughly until every particle of bran was damp. In each case approximately one level teaspoonful of the bait was scattered over the bottom of the tin which had an area of approximately 82.5 square inches. Each larva therefore could choose between fresh alfalfa foliage and the poisoned bran bait in each tin. Each of the three insecticides was used in three concentrations as shown in Table 1. Each experiment was replicated four times. On May 28 the first ten lots with nine baits and the check were started. This was followed on each of the three succeeding days by other ten lots of 20 cutworms each. In every instance each lot was examined and counts recorded of dead, dying and active cutworms at 24, 48 and 72 hour intervals. Eight hundred cutworm larvae were used in these experiments. Additional cutworms from the collection made on May 26 were reared and the resulting adults were identified as indicated previously.

**RESULTS AND DISCUSSION.**—Each of the insecticides was used at the rate of one part actual chemical to 166 parts bran, to 83 parts bran and to 41 parts bran, respectively, as shown in Table I where the results of each experiment are the average of the four replicated treatments. Table 1 shows that of the three insecticides used, Hyman compound 269 consistently killed the most cutworms at the end of 24, 48 and 72 hours at all three rates of application. This also holds true for the combined dead and comatose cutworms for these same intervals. Although Hyman compound 269 kills more quickly than either aldrin or dieldrin as shown by the comparative number of dead cutworms at the end of 48 hours, our observations of the behavior of all cutworms indicated that little or no apparent feeding of alfalfa took place after the bait had been given to them, especially after the first 24 hours. Mitchener (1928) showed that at the end of 72 hours, paris green in the regular bait used at that time killed 11.6 per cent and calcium arsenate 8.3 per cent of the dark-sided cutworm, *Euxoa messoria* (Harr.) and calcium arsenate 8.3 per cent of the dark-sided cutworm, *Euxoa messoria* (Harr.) and that at the end of the tenth day approximately only 50 per cent were dead where each of these poisoned baits was used. Hyman compound 269 in the present instance killed a very high percent of the cutworms at the end of 72 hours as shown by Table 1 and immobilized 100 per cent by that time. Both aldrin and dieldrin also gave relatively good results. The relatively poorer results for the bait containing one part dieldrin to 83 parts bran is due to the results of replicates 3 and 4 which for some unknown reason were less effective than replicates 1 and 2 for that experiment. Any one of the three insecticides gave good practical control at each of the three concentrations used. It is probable that a smaller percentage of each poison to the bran would give satisfactory kills but only further experimental work will determine if this is true.

Each of the chlorinated hydrocarbons used, probably kills as a contact poison and also as a fumigant. It is not likely that the cutworms were affected by any fumigant action as they were in open tins in a large room. It is possible that they may have been affected by coming in contact with the poisoned bran. Further experimental work should be undertaken to determine if there is any lethal contact or fumigant effect under conditions similar to those of these experiments or in the field.

Table I  
THE LETHAL EFFECTS OF ALDRIN, DIELDRIN AND HYMAN COMPOUND 269 USED AT THREE CONCENTRATIONS  
IN A BRAN-WATER BAIT ON A MIXED POPULATION OF CUTWORM LARVAE.

Insecticide	Experi- mental Number	Ratio of Insecti- cide to bran	24 hours after baiting			48 hours after baiting			72 hours after baiting		
			% dead	% dying	% active	% dead	% dying	% active	% dead	% dying	% active
aldrin	1	1-166	13.9	77.2	8.9	56.2	42.5	1.3	79.7	17.7	2.5
aldrin	2	1-83	22.5	66.2	11.2	59.4	36.7	3.8	77.2	20.2	2.5
aldrin	3	1-41	11.2	87.5	1.2	58.2	40.5	1.2	92.4	7.6	0.0
dieldrin	4	1-166	3.8	85.9	10.2	45.3	49.4	5.2	73.7	26.3	0.0
dieldrin	5	1-83	8.8	70.9	20.2	48.1	39.2	12.6	67.1	24.0	8.8
dieldrin	6	1-41	11.4	87.3	1.3	63.3	35.4	1.3	89.8	10.1	0.0
Hyman com- pound 269	7	1-166	15.0	83.7	1.3	75.0	25.0	0.0	95.0	5.0	0.0
Hyman com- pound 269	8	1-83	22.5	76.2	1.3	70.0	30.0	0.0	93.6	6.4	0.0
Hyman com- pound 269	9	1-41	21.8	78.2	0.0	73.1	26.9	0.0	92.3	7.7	0.0
Checks	10	0	1.3	1.3	97.4	1.3	1.3	97.4	1.3	1.3	97.4

NOTE: Each experiment was replicated four times at 24 hour intervals with 20 cutworms in each replicate. The results are the averages of the four replicates for each experiment.

SUMMARY.—(1) Aldrin, dieldrin and Hyman compound 269 each gave excellent control in a bran-water bait under the conditions of these experiments for the cutworms mentioned.

(2) Hyman compound 269 killed more quickly than either aldrin or dieldrin at each of the three concentrations used.

(3) After a 24 hour exposure to each bait, and particularly to Hyman compound 269, relatively few of the cutworms were active enough to feed at that time or thereafter.

ACKNOWLEDGMENTS.—The author received financial assistance for these experiments on an equal basis from Julius Hyman and Company, Denver, Colorado and Shell Chemical Corporation, New York City. The aldrin, sample No. 6992, the dieldrin, sample No. 6994 and the Hyman compound 269, sample No. 7010 were supplied by Julius Hyman and Company. I wish also to acknowledge the help of Messrs. B. Furgala and A. L. Steinhauer, student assistants in the Department of Entomology. Mr. J. B. Wallis, Winnipeg, who is associated with this Department, identified adult moths reared from some of the larvae collected. To each and all of these I wish to express my thanks.

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### TRIALS OF ACARICIDES AGAINST THE EUROPEAN RED MITE, *METATETRANYCHUS ULMI* (KOCH), ON APPLE<sup>1</sup>

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Three acaricides are recommended at the present time for the control of the European red mite, *Metatetranychus ulmi* (Koch), on apple in Ontario: 1 per cent summer oil, DN-Dry Mix No. 1<sup>3</sup>, and parathion.

Many growers claim that the summer oil spoils the finish of the fruit and do not use it, although it has given effective and economical control. This material has another disadvantage in that DDT cannot be used with it in direct combination. DN-Dry Mix No. 1 has too frequently not given effective control and has definite phytotoxic hazards. Parathion has given very effective immediate reductions of European red mite populations but its use is frequently followed at various intervals by increased populations. In addition, parathion is phytotoxic, particularly to McIntosh and related varieties of apple, is highly toxic to mammals, including man, and seriously reduces populations of beneficial parasites and predators in the orchard environment. The disadvantages of these materials are sufficient to justify their replacement as soon as better ones can be demonstrated experimentally.

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<sup>3</sup>40 per cent dinitro-o-cyclohexylphenol.



## METHODS AND MATERIALS

Plots containing 17 to 18 trees were used in 1949, and included in each were the apple varieties Astrachan, Duchess, Jonathan, McIntosh, and Yellow Transparent. The total number of trees per plot was slightly reduced during 1950, ranging from 13 to 17 trees each. There were 4 McIntosh trees in each plot in each year.

Weekly samples of one leaf per McIntosh tree were taken at random at shoulder height from each plot during 1949 and 1950. As these samples were very small, they could not be expected to give a highly accurate measure of the mite populations in the various plots, but it is considered that the population trends were reasonably well indicated for the two seasons.

In 1951 there were 6 McIntosh trees in each plot. Samples of 25 leaves were taken weekly from each of the two centre McIntosh trees in each plot. The remainder of the trees on either side of the record trees served as buffers to prevent contamination by drifting spray.

In each season the sample leaves were examined microscopically and all stages of the European red mite except the eggs were recorded. The weekly records were averaged to give the monthly population per leaf.

All sprays were applied with a conventional power machine and hand gun. Approximately 6 to 8 gallons of spray mixture were applied per tree, the trees being 9 years old in 1949, the higher amounts being applied later in the season when the foliage was most dense. The acaricides were used in combination with the insecticides and fungicides recommended for use on apple in Ontario.

Specifications and sources of the materials were as follows:—

*Ethyl p-nitrophenyl thiobenzenephosphonate* (EPN-300). — 27 per cent wettable powder. Canadian Industries Limited.

*Parathion*. — Fifteen and 25 per cent wettable powders, from various sources.

*p-chlorophenyl p-chlorobenzenesulphonate* (C-854 and C-1006). — Fifty per cent wettable powder. Dow Chemical Company, Midland, Michigan. C-1006 is said to contain a more refined active ingredient, and is now named Ovotran.

*p-chlorophenyl phenyl sulphone* (R-242). — Twenty-five per cent *p*-chlorophenyl phenyl sulphone and 15 per cent related aromatic sulphones, wettable powder. Stauffer Chemical Company, Los Angeles, California.

Emphasis was placed on the application of the acaricides early in the season for the reasons following: (1) It seemed probable that toxic residues at harvest would be avoided, (2) better coverage would be obtained because of low foliage density, (3) phytotoxic effects, if any, were likely to be more pronounced, and (4) any effective reduction of the mite population when it was at a seasonably low level would possibly last for a long time.

## EFFECTS OF THE ACARICIDES ON THE EUROPEAN RED MITE

1949. — Parathion, 25 per cent wettable powder, was used in the pink (May 3) and calyx (May 18) sprays with wettable sulphur and arsenate of lead. C-854 was used in the prepink (April 25) spray with bordeaux, 7½-10-100, or in the second (June 11) and fourth (July 4) cover sprays with ferbam and arsenate of lead.

Table I shows that parathion was very effective, even into July, but that it permitted or caused a rapid increase in the mite population in August. The application of C-854 in the prepink spray alone gave surprisingly effective control throughout May and June, but control was inadequate for the remainder of the season. The two sprays of C-854 in the second and fourth covers caused a marked reduction in the European red mite population during the latter part of June and this reduction was well maintained throughout July and August.

Table I

EFFECTIVENESS OF ACARICIDES AGAINST THE EUROPEAN RED MITE,  
HARROW, ONT., 1949

<i>Acaricide</i>	<i>Pounds per 100 gal.</i>	<i>Spray dates</i>	<i>Average number of mites per leaf</i>			
			<i>May</i>	<i>June</i>	<i>July</i>	<i>August</i>
Parathion (25%)	0.5	May 3 & 18	0.0	0.9	9.7	42.8
C-854 (50%)	1.5	April 25	0.0	1.0	22.6	14.1
C 854 (50%)	2.0	June 11 & July 4	0.4	9.3 (1.2*)	3.7	7.3
Check	—	—	0.6	24.4	68.0	4.6

1950. — Parathion, 15 per cent wettable powder, was applied in the pink (May 17) and calyx (May 29) sprays in combination with wettable sulphur and arsenate of lead. EPN-300 was used with wettable sulphur and arsenate of lead in the pink and calyx sprays. C-1006, with wettable sulphur and arsenate of lead, was applied in the calyx (May 29) and first cover (June 8) sprays.

Table II

EFFECTIVENESS OF ACARICIDES AGAINST THE EUROPEAN RED MITE,  
HARROW, ONT., 1950

<i>Acaricide</i>	<i>Pounds per 100 gal.</i>	<i>Spray dates</i>	<i>Average number of mites per leaf</i>				
			<i>May</i>	<i>June</i>	<i>July</i>	<i>August</i>	<i>September</i>
Parathion (15%)	1.0	May 17 & 29	0.0	0.0	0.0	0.2	1.3
EPN-300 (27%)	1.0	May 17					
	0.5	May 29	0.0	0.2	0.0	0.2	0.7
C-1006 (50%)	2.0	May 29 & June 8	0.0	0.0	0.0	2.1	1.4
Check	—	—	0.7	1.6	13.2	50.1	0.5

Table II shows that comparable effective control of the European red mite was obtained throughout the 1950 season with each of the three materials. The slightly higher population in the C-1006 plot during August was probably a result of contamination from the adjacent check plot.

1951. — Parathion was dropped from the program to provide larger plots and to permit the use of C-1006 in several differing schedules. A preventive type of schedule, in part as suggested by the manufacturer of this material, consisted of using one-half pound per 100 gallons of spray mixture in the pink (May 8), calyx (May 25), and first (June 5) and second cover (June 15) sprays. A second modified schedule included the use of C-1006 at 1 pound per 100 gallons of spray mixture in the calyx and first and second cover sprays. In this series the C-1006 was used in combination with wettable sulphur, arsenate of lead, or DDT. Hydrated lime was used in the pink spray only and DDT in the two cover sprays. R-242 was included in the experiment for the first time, and was used at 2 pounds per 100 gallons in the calyx and first cover sprays in combination with wettable sulphur, arsenate of lead, or DDT.

\*After application of June spray.

Table III  
EFFECTIVENESS OF ACARICIDES AGAINST THE EUROPEAN RED MITE,  
HARROW, ONT., 1951

<i>Acaricide</i>	<i>Pounds per 100 gal.</i>	<i>Spray dates</i>	<i>Average number of mites per leaf</i>			
			<i>May</i>	<i>June</i>	<i>July</i>	<i>August</i>
C-1006 (50%)	0.5	May 8 & 25, June 5 & 15	0.8	0.0	0.0	1.3
C-1006 (50%)	1.0	May 25 June 5 & 15	3.3	1.2	0.0	2.3
R-242 (40%)	2.0	May 25 & June 5	5.2	0.2	5.5	19.9
Check	—	—	2.3	7.3	56.1	18.6

Table III shows that C-1006 in the preventive schedule beginning at the pink stage gave very effective control throughout the season. Although C-1006 used at 1 pound in three sprays commencing at the calyx stage gave satisfactory control, this method was more costly and not so effective. R-242 gave adequate control during June and the first half of July but not for the remainder of the season. This experiment probably did not give an adequate measure of the effectiveness of R-242 as this plot was affected by movement of mites from the check plot during July and early August. It is probably not valid to compare the 1951 results with those of 1950, but Tables II and III show that C-1006 used in 1950 at 2 pounds per 100 gallons in the calyx and first cover sprays gave control superior to that obtained with R-242 at the same rate in these sprays during 1951.

The results obtained with C-1006 in 1951 further supported the evidence of the effectiveness of the material for control of the European red mite on apple. It appears that it should be given large scale trials in commercial orchards during 1952, and could be substituted for parathion in the Ontario Spray Calendar for Apples.

#### COMPATIBILITY AND PHYTOTOXICITY

In the two years it was used, parathion showed no apparent incompatibility with wettable sulphur or arsenate of lead. The 25 per cent wettable powder used in 1949 in the pink spray at one-half pound per 100 gallons caused slight marginal burning and cupping of McIntosh leaves but no fruit injury. A trace of burning of foliage occurred on Yellow Transparent from the same application. None of the other varieties in the block was injured.

EPN-300, used in 1950 only and then with wettable sulphur and arsenate of lead at 1 pound per 100 gallons in the pink spray, caused severe burning and dropping of leaves of McIntosh. The injury became evident four days after the spray was applied. Injury was caused to fruit also at this time and became most evident at harvest as a severe type of russetting. It is probable that this spray affected the development of fruit buds, as the four trees that were severely injured were the only ones in the entire orchard that had few blossoms and a poor crop in 1951.

In these experiments C-854 or C-1006 was used with various combinations of bordeaux mixture, ferbam, wettable sulphur, hydrated lime, lead arsenate, and DDT. There was no evidence of incompatibility with any of these materials. No evidence was obtained of phytotoxic effects of C-854 or C-1006 on any of the five apple varieties in the orchard, when used either in pre-blossom or post-blossom sprays.

There was no apparent incompatibility of R-242 with wettable sulphur, arsenate of lead, or DDT, nor did this material cause any injury as it was used in 1951.



## ACKNOWLEDGMENTS

The writer wishes to thank Mr. E. J. LeRoux for his assistance with the experiments during 1950 and 1951, particularly for his undertaking of the tedious recording of the mite populations.

## SUMMARY

At Harrow, Ontario, p-chlorophenyl p-chlorobenzenesulphonate, as a 50 per cent wettable powder, gave consistently effective control of the European red mite on apple for three seasons, without introducing problems of incompatibility or phytotoxicity. As this material has low human toxicity it should serve as an effective and less hazardous substitute for parathion in the control of the European red mite in Ontario.

In a trial for one season only, R-242 did not appear to give satisfactory control over a sufficient period.



LIFE-HISTORY STUDIES OF THE CRANBERRY FRUITWORM,  
*MINEOLA VACCINII* (RILEY), IN NEW BRUNSWICK  
(LEPIDOPTERA: PYRALIDAE)<sup>1</sup>

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## INTRODUCTION

The cranberry fruitworm, *Mineola vaccinii* (Riley), is a serious pest of cranberries in both cultivated and natural bogs in New Brunswick, 80 per cent of the crop sometimes being ruined in untreated areas. In some years results of field control tests have been inconsistent, due partly, it is believed, to improper timing of the initial insecticidal application, the timing having been based on the development of cranberry bloom for the cranberry growing areas of the New England States. To determine the proper timing, the life-history of the fruitworm in New Brunswick and its relationship to the development of the cranberry were investigated in 1950 and 1951. Studies were conducted near the centre of the cranberry growing area of the province, at Cumberland Point, Grand Lake, Queens County.

Smith (1884, pp. 28-29), who discovered the insect, studied its life-history in Massachusetts. Riley (1884) described the insect and named it *Acrobasis vaccinii*. This name remained valid until 1890, when Hulst (1890) reorganized the family, placing the species in a new genus, *Mineola*. Scammell (1917, pp. 20-22) reported that the adults emerged in June and July and that the eggs were laid in the calyx cup under the lobes, or on any part of the berry. Chambers (1929, p. 113) reported that no satisfactory method of control of the insect had been devised. Crowley (1937) recommended that sprays for control should be applied as soon as the moths emerged. Franklin published a series of reports on cranberry pests, his first appearing in 1907. In 1948 (pp. 51-56) he stated that the egg is usually laid under one of the lobes of the blossom end of the berry but sometimes elsewhere on the surface. He stated further that moths are in flight from very late May till after mid-August. He indicated that the first application should be made when half the vines are past bloom. The New Jersey spray calendar (Tomlinson *et al.*) for 1951 recommended that the first application be made two weeks after mid-bloom.

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## LIFE-HISTORY AND HABITS

*Methods*

Records of the emergence of adults were obtained by making daily collections from cages in the cranberry bog under study. The cages were four feet square and 40 inches high, the sides being of cotton and the tops of 18-mesh wire screen. They were placed in four rows of three cages per row before the appearance of bloom. In 1951, the second season of the study, the cages were removed to new positions on the bog. Efforts at collecting by the use of light traps placed on the bog were unsuccessful, although many other species of moths were taken.

All records of egg, larval, and cranberry development were obtained by making thrice-weekly examinations in the field laboratory of at least 500 blossoms or berries per examination. These examinations extended from the beginning of bloom to the end of fruitworm activity.

Data for the development curves of the cranberry (Fig. 3) were obtained by collecting daily samples of vines throughout the blooming period and counting the number of blossom buds, opened blossoms, and berries in each sample. These were converted into percentages and presented in graph form. For any one date the percentages of buds, blossoms, and berries total 100 per cent.

*Adult*

In 1950 the emergence period extended from June 15 to July 26, 138 males and 106 females being collected, and the mean day of emergence occurred on July 9 (Fig. 1).

In 1951, although the emergence period was over three weeks shorter, the mean day of emergence occurred on July 8 (Fig. 1).

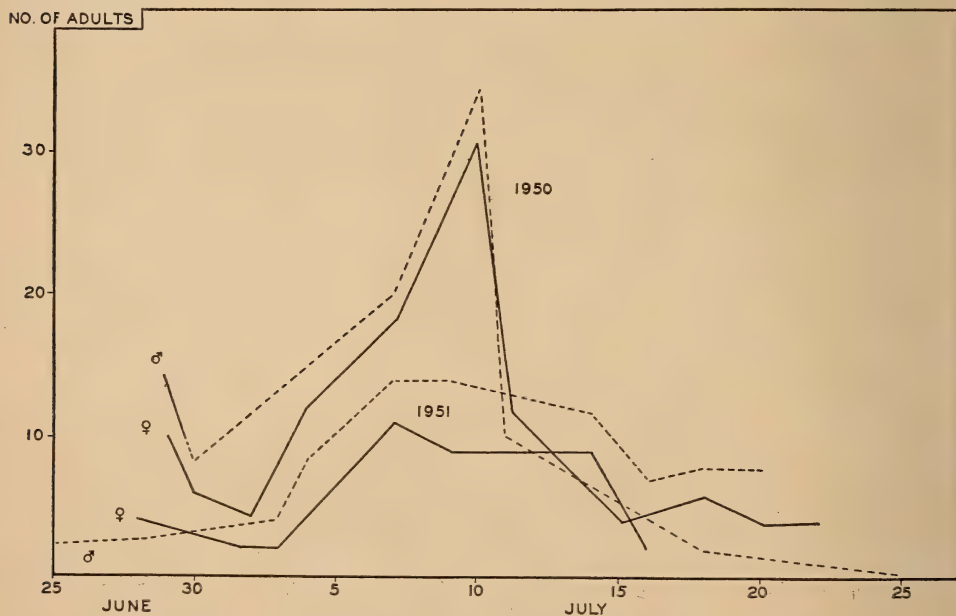


Fig. 1. Emergence of adults of *Mineola vaccinii* in New Brunswick, 1950, 1951.

*Egg*

Eggs were found in the bog from July 2 to July 19 in 1950 (Fig. 2), and from July 3 to July 22 in 1951. They were found typically against the inside lip of the calyx cup of the newly formed berry and only after the petals had fallen. Eggs were also present on the leaves, stipules, and bracts at the base of the berry stem. In no case was more than one egg found on one berry.

When laid the egg is a soft, ovoid, and almost transparent droplet, which conforms to the shape of the material on which it is laid. In a few hours the egg gels slightly, becoming more opaque, and after a day turns a light brown colour. By the fourth day the colour has darkened and the larva may be seen through the chorion. The egg hatches on the sixth day; however, eggs parasitized by *Phanerotoma franklini* Gahan take up to eight days to incubate.

#### Larva

In hatching, the larva typically eats its way out of the side of the egg shell and bores immediately into the seed chamber of the berry, the whole process requiring only a few minutes. The newly hatched larva is about 0.2 mm. long and slightly yellow in colour, without markings; later instars vary from greenish to reddish, the head capsules being amber. After eating one or two seeds, the larva moults within the berry; in the second instar it leaves the berry, making a new exit hole, and enters another berry by tunnelling into the side. After making an entrance it weaves a silken plug or curtain over the hole. The larva continues to feed in the berry until it moults into the third instar. It now eats its way out of the berry and enters a third, making its entrance in the same manner as for the second instar. In the fourth and succeeding instars one or more berries may be attacked, no attempt being made to close the entrance hole. In the sixth instar the larva feeds for a short time — less than a week — then drops to the ground and spins a silken hibernaculum, in the construction of which sand and debris adhere to the outside, giving it the appearance of a small lump of sand. The larva remains in the hibernaculum until the latter part of May of the following year, when pupation occurs. Fig. 2 shows the periods during which the stages of the insect are found.

At the time of attack by first- and second-instar larvae, injury to the fruit is almost indiscernible. However, later in the season injured berries turn red prematurely. Often in later instars the larva devours the pulp of the berry, leaving only the skin, which later collapses and turns brown. The injury caused to ripened berries late in the season is often indicated only by the entrance hole.

#### Parasites

Along with the moths in the cages, adults of *Phanerotoma franklini* Gahan, a cranberry fruitworm parasite, were collected in significant numbers. Several specimens of the parasite *Cryptus albitarsis albitarsis* (Cress.) were reared from overwintering larvae.

Table I

DATA ON THE LARVAL INSTARS OF *MINEOLA VACCINII* IN NEW BRUNSWICK, 1950

Instar	Head capsule (mm.)		Occurrence			Estimated percentage of blossoms past
	average	range	range, days	mean day	duration days	
I	0.18	0.15–0.24	14	July 16	1	80
II	0.43	0.34–0.49	14	July 17	5	80
III	0.63	0.54–0.73	20	July 22	9	95
IV	0.86	0.78–0.97	27	July 31	9	100
V	1.08	1.02–1.26	26	Aug. 9	16	
VI	1.37	1.36–1.46	15	Aug. 25	5	
(plus hibernation)						

#### RELATION OF FRUITWORM LIFE-HISTORY AND CRANBERRY DEVELOPMENT

The mean day of adult emergence followed close upon the peak of bloom (Fig. 3). Eggs were first found when the number of blossom buds equalled the number of opened blossoms. This marked the beginning of blossom fall, or the appearance of set fruit (Fig. 3). The incubation period of the egg extended six days, larvae first being found on July 10 in 1950



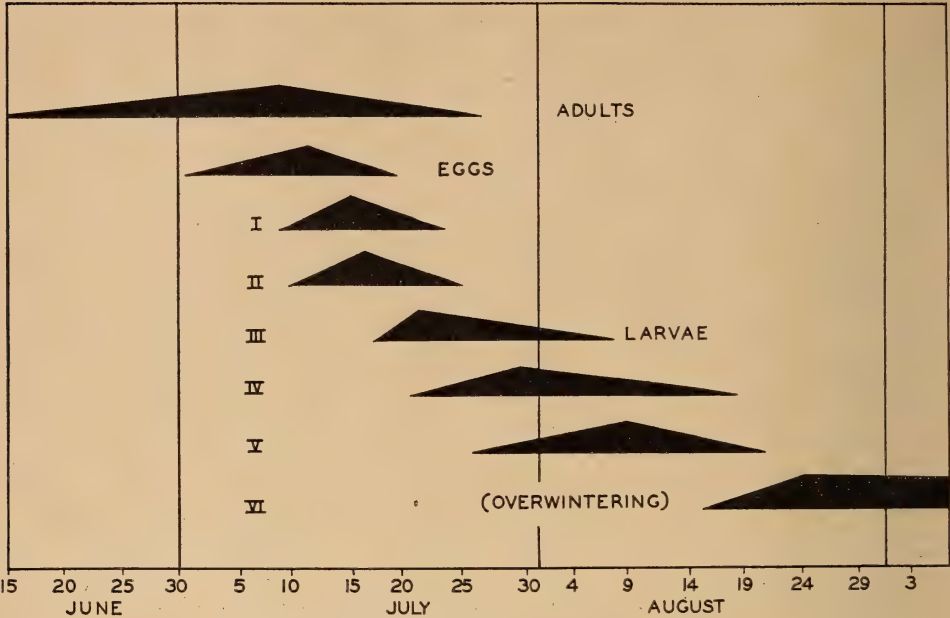


Fig. 2. Durations of stages of *M. vaccinii*, 1950.

(Fig. 2) and in 1951. Two or three days after the peak of bloom and the mean day of adult emergence the remaining few blossoms buds had come into bloom and the number of berries equalled the number of blossoms (Fig. 3). The mean day of abundance of newly hatched larvae occurred about five days after 50 per cent of the berries had formed and was closely followed by the mean day of abundance for the second-instar larvae, the duration of the first instar being only one day. The mean day of abundance for the third instar occurred just before the end of bloom. Sixth-instar larvae appeared in mid-August and by harvest time had left the fruit to hibernate (Fig. 2).

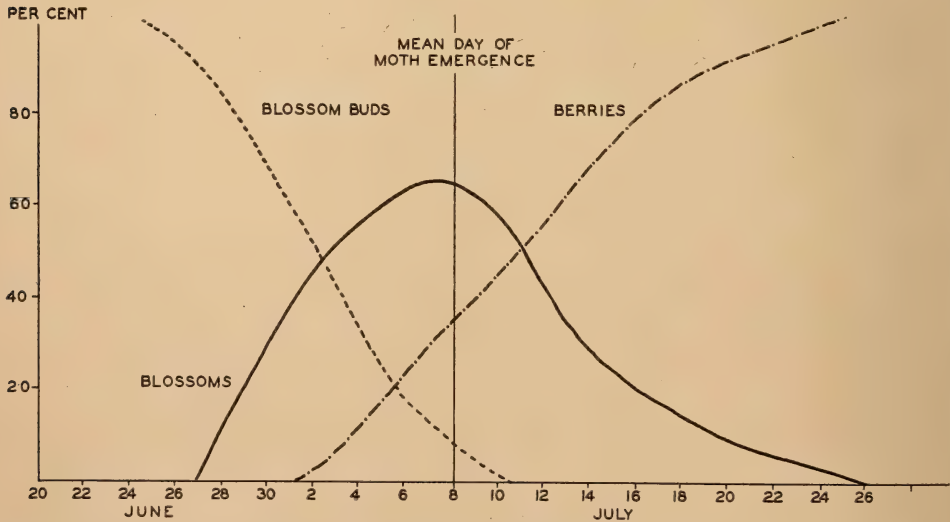


Fig. 3. Relation of moth emergence to cranberry development. For any date the percentages of blossom buds, blossoms, and berries total 100.

It seems therefore that the initial insecticide application should be made as soon as the first eggs have hatched, that is, immediately after the peak of bloom, or when the last of the blossom buds have come into bloom.

#### SUMMARY

Daily records of emergence of adults of *Mineola vaccinii* (Riley) in New Brunswick in 1950 and 1951 indicated that the mean day occurred on July 8 or July 9. Comparison of data on the life-history with those on cranberry development indicated that the initial application for control should be made immediately after the peak of blossoming, when the first eggs of the insect have hatched.

#### ACKNOWLEDGMENTS

The writers appreciate the assistance of Mr. Floyd A. Wood in the collection of much of the field data for this study.

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## THE OVERWINTERING HABITS OF THE STRAWBERRY WEEVIL, *ANTHONOMUS SIGNATUS* SAY (COLEOPTERA: CURCULIONIDAE), IN NEW BRUNSWICK<sup>1</sup>

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A number of authors have stated that the strawberry weevil, *Anthonomus signatus* Say, passes the winter in thickets, woodlands, fence rows, and other sheltered places. For example, Marcovitch (1922) wrote that in Tennessee the weevils hibernate in woods and thickets and that strawberries should not be planted next to them. Marlatt (1928, p. 21) reported that the weevils

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feed on wild plants but that as soon as strawberry buds appear they move from the woodlands to strawberry fields. Stearns (1937, pp. 120-121) stated that over 90 per cent of the weevils overwinter in sheltered situations within 100 feet of the strawberry plantations, and recommended burning over their hibernation quarters.

#### HIBERNATION OF WEEVILS IN RASPBERRY PLANTATIONS

Four commercial raspberry plantations, known to be infested with the strawberry weevil during the bud-cutting period, were examined in the fall of 1941, when they had a fairly deep covering of fallen raspberry and other leaves. Searches made of this debris and also of the floor of adjacent evergreen woods did not reveal any weevils, but later in the fall, when carefully collected debris from the plantations was placed over screens in temperature cabinets at 80° F. weevils were found in large numbers, with an average of 50 and a maximum of 187 per bushel of debris. The extent to which the weevils may winter beneath the surface of the soil was not determined, but debris frozen to the surface and including about half an inch of the soil yielded approximately as many weevils as were found in the debris alone. More weevils were taken in debris that was wet and settled than in dry, loose material. It was found that the debris must be collected with as little disturbance as possible, few weevils being found when it was raked into piles or pulled from among weeds.

In the following spring weevils were again collected from the debris in considerable numbers.

During the bud-cutting period in 1942 a wire screen cage was built around a group of canes in one of the plantations. The following year, injury was as heavy within the cage as in other parts of the plantation.

Two of the plantations were surrounded by open fields whereas the other two were adjacent to evergreen woods; there was no indication that the proximity to woodlots had any effect on weevil abundance.

#### OVERWINTERING OF WEEVILS IN STRAWBERRY PLANTATIONS

Attempts to collect the weevil from strawberry plantations in the fall by the method used in the raspberry plantations were not successful, because the debris could not be removed without too much disturbance. Neither were any weevils found by careful examination of sods of strawberry plants removed from the rows.

In early spring two cages, each 10 feet long, 8 feet wide, and 9 inches high and covered with black paper, were placed in the plantation where the sod had been examined the previous fall. Shortly before feeding activity was noticed on the plants, weevils began to appear in glass vials inserted in the cages, and continued to do so for about a month. In similar cages placed much later in the season in a number of plantations, weevils did not appear in the vials. However, in the following spring weevils appeared in numbers in a few cages left in position during the winter. Only three or four weevils were collected in weekly sweepings made in various plantations during the summer. Wire screen painted with diluted Tanglefoot, which was renewed regularly, was suspended across the rows in a heavily infested plantation, but few or no weevils were collected on it after the bud-cutting period.

Over a ten-year period beginning in 1942, two cotton-topped cages were placed each week during the summer and fall in each of two strawberry plantations from which one crop had been picked. Early in the spring they were covered with black building paper and glass vials were inserted in the sides. Weevils were removed from the vials daily during the emergence period. The numbers collected are given in Table 1. The most significant part of the data is the relative constancy of the average number of weevils collected per cage, irrespective of the time when they were placed in the plantations, this value varying from 5.3 to 6.5. These results show that the weevils are practically inactive from July through October, and that little or no movement from or to the plantations occurs during this time.



Table 1  
Numbers of the Strawberry Weevil Collected in Spring from Cages Set Up During the Previous Summer

Year	Plantation	July			August			Cages set up			September			October			Average per cage	Mean date collection
		No. cages	Weevils collected	No. cages	No. cages	Weevils collected	No. cages	Weevils collected	No. cages	Weevils collected	No. cages	Weevils collected	No. cages	Weevils collected	No. cages	Weevils collected		
1942	A	4	130		8	376		8	350		10	300		38.5	May 13			
	B	4	16		8	16		8	14		10	25		2.3	" 13			
1943	A	6	4		8	15		8	8		10	3		1.0	" 24			
	B	6	16		8	10		8	12		10	21		1.9	" 26			
1944	A	2	2		8	40		10	39		8	24		3.6	" 21			
	B	2	5		8	13		10	23		8	10		2.9	" 19			
1945	A	No record			10	16		8	16		8	25		2.2	" 17			
	B	"			10	26		8	19		8	11		2.2	" 17			
1946	A	2	2		8	14		8	10		6	4		1.2	" 31			
	B	2	4		8	63		8	37		6	28		5.5	" 30			
1947	A	2	13		8	36		8	38		8	28		4.4	" 29			
	B	2	2		8	57		8	80		8	48		7.2	" 30			
1948	A	No record			10	34		8	45		6	34		4.7	" 31			
	B	"			10	70		8	49		6	24		6.0	June 1			
1949	A	"			8	29		10	39		6	27		3.9	May 20			
	B	"			8	9		10	10		6	8		1.1	" 22			
1950	A	"			8	37		10	93		6	29		6.6	" 24			
	B	"			8	92		10	52		6	53		8.2	" 22			
1951	A	"			10	53		8	45		8	41		5.3	" 17			
	B	"			10	107		8	75		8	62		9.4	" 17			
Average per cage			6.1			6.5			6.1			5.3						

## OCCURRENCE OF WEEVILS IN AREAS ADJACENT TO STRAWBERRY PLANTATIONS

During the early years of the study, searches were made for weevils among bushes along property lines adjacent to plantations and in nearby coniferous and deciduous woods and neglected orchards. No evidence of the weevil was found except an occasional cut bud on wild strawberries or raspberries. Numbers of cages were placed in these areas before the spring emergence of the weevils, but no weevils were found except a few in a cage among wild raspberries.

## FACTORS AFFECTING WINTER SURVIVAL IN THE PLANTATIONS

Surveys have shown that successful hibernation in the plantations depends on the presence of suitable cover, which may be of various forms. More weevil injury usually occurs in the most vigorous plantations that have suffered little from winter injury than in weakly-growing plantations planted in areas exposed to winter conditions. Weevil damage is also more prevalent where the plants were well protected by straw. Snow cover is very important; weevil injury tends to be most severe in plantations or parts of plantations where the snow was deepest the previous winter. As snowdrifts accumulate near fence rows, woods, and other shelter, strawberries in such situations suffer most from weevil attack.

After harvesting one crop many growers in New Brunswick burn over their plantations early in the following spring. That this practice has no apparent effect on the weevils was illustrated at various times by the collections of approximately equal numbers of weevils in cages placed on burned and unburned parts of the plantations.

Tests were conducted to determine whether ploughing a plantation would eliminate it as a source of infestation. Parts of plantations were ploughed and harrowed once, and cages immediately placed on both the ploughed and the unploughed areas. The following spring weevils were collected only from the cages on the unploughed land.

## SUMMARY

In New Brunswick the strawberry weevil hibernates largely within strawberry and raspberry plantations, and not, as usually stated, in surrounding areas. After reaching maturity the adults remain relatively inactive until the following spring. Successful hibernation is dependent on adequate cover, furnished by vigorous plant growth, straw, or snow. Burning of strawberry plantations in early spring has little or no effect in reducing the number of weevils and associated injury. The weevils do not survive when plantations are ploughed.

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CHEMICAL CONTROL OF THE CURRANT FRUIT FLY,  
*EPOCHRA CANADENSIS* LOEW (DIPTERA: TRUPANEIDAE),  
IN MANITOBA<sup>1</sup>

H. P. RICHARDSON<sup>2</sup>, A. G. ROBINSON<sup>2</sup>, and W. R. ALLEN<sup>3</sup>

INTRODUCTION

The currant fruit fly, *Epochra canadensis* Loew, is a serious pest of currants and gooseberries. In Manitoba annual losses have discouraged the growing of these fruits and have caused growers to uproot established plantings.

Experiments on the control of the currant fruit fly have been conducted in Manitoba since 1943. Bird (1946) recommended the use of cryolite and molasses; Allen and Bird (1948) again recommended cryolite and molasses and tentatively recommended DDT. Andison *et al.* (1951) recommended DDT only. Recent experiments have shown that methoxychlor is as effective as DDT.

The results presented in this paper were obtained from a laboratory experiment conducted in 1946 and from field experiments conducted in 1947, 1950, and 1951.

LABORATORY EXPERIMENT

In 1946, an experiment was conducted in the insectary at Morden on the residual toxicity of DDT sprays applied at various concentrations to currant to control the adult.

*Materials and Methods*

Plots consisted of single bushes of red currant. There were 3 series, each consisting of 5 plots triplicated.

Series 1 received 1 application; Series 2, 2 applications; and Series 3, 3 applications of DDT at weekly intervals. The DDT was applied in sprays containing  $\frac{1}{8}$ ,  $\frac{1}{4}$ ,  $\frac{1}{2}$ , 1 and 2 lb. of actual toxicant in 100 gal. of water to the 5 plots, respectively, of each series.

The flies were reared from puparia sifted from the soil in the spring and kept in a constant temperature room at 50° F. and 90 per cent relative humidity. At this temperature the normal emergence period was lengthened by 2 weeks.

Two currant shoots were taken from each plot of each series 1 week after spraying. The stems of each pair of shoots were inserted into a vial of water and placed in a pyramidal 14-mesh wire screen cage together with 10 flies and a vial containing a food mixture of honey, yeast, and water. The number of dead flies was recorded daily for 1 week. The test, whenever sufficient flies were available, was repeated 2 and 3 weeks after spraying.

*Results and Discussion*

Table I shows that the DDT residue from 1, 2, or 3 applications at  $\frac{1}{8}$  and  $\frac{1}{4}$  lb. gave a comparatively low average mortality, not exceeding 50 per cent. The  $\frac{1}{2}$ -lb. rate was somewhat better and the 1-lb. and 2-lb. rates were good, there being a positive relationship between mortality and concentration throughout the range tested. The efficiency of the higher concentrations was increased by an increase in number of applications. The toxicity persisted for at least 3 weeks after application.

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Table I

MORTALITIES OF CAGED ADULTS OF THE CURRANT FRUIT FLY  
EXPOSED TO DDT-SPRAYED FOLIAGE FOR 7 DAYS

1946

No. applications	No. weeks after final application	No. insects tested per concentration	Percentage mortality DDT, lb. actual per 100 gal.					Check
			1/8	1/4	1/2	1	2	
1	1	30	33	43	43	66	83	13
1	2	30	20	30	33	40	70	13
1	3	10	20	40	50	70	70	0
2	1	30	30	43	56	73	96	26
2	2	10	10	50	100	100	100	20
3	1	10	30	50	100	100	100	20

## FIELD EXPERIMENTS

*Materials and Methods*

Investigations have shown that consistent experimental results may be obtained only where currant and gooseberry plots are sufficiently isolated to minimize the effect of the movement of the flies. In 1947, 1950, and 1951 the plots were at least a mile apart, in private plantings, and there were no other plantings within 1 mile of each; a planting comprised one plot. The plots were duplicated.

In 1947, 2 DDT treatments were used. One treatment consisted of DDT at 1/2 lb. of actual toxicant per 100 gal. of water applied at cessation of bloom, and again 4 and 11 days later. In the other treatment, DDT was applied at the same rate 4 and 11 days after bloom.

In 1950, 2 treatments of DDT and 1 treatment of methoxychlor were compared. Treatment 1 consisted of 2 lb. of actual DDT per 100 gal. of water applied just before the flowers buds opened and two post-blossom sprays of 1/2 lb. of actual DDT per 100 gal. of water. Treatment 2 consisted of DDT, and treatment 3 of methoxychlor, applied at 1/2 lb. of actual toxicant per 100 gal. of water in 2 post-blossom applications. In all 3 treatments the post-blossom sprays were applied when 80 per cent of the fruit had set and again 8 or 10 days later.

In 1951, DDT and methoxychlor were again compared by repeating treatments 2 and 3 of 1950.

A 3-gal. compressed air sprayer was used to apply sprays, which were made from 50 per cent wettable powders.

*Sampling and Rearing.* — In 1947, half a pint of fruit was picked at random from each plot on each of 3 dates 10 days apart. In 1950 and 1951, one pint was picked at random from each plot on each of 3 dates 7 days apart. In each year the first sample was taken 8 to 12 days after the last post-blossom spray.

The rearing methods in 1947 were different from those in 1950 and 1951. In 1947 the sample was placed in either a 6-mesh wire basket or an 8-mesh cloth bag and suspended in a pint-sized waxed paper carton. This method provided conditions conducive to growth of mould. In 1950 and 1951 the berries were spread out on a 6-mesh wire screen over a large empty clay pot.

The larvae emerged from the fruit and fell to the bottom of the container, where they formed puparia. The percentage infestation was determined by

$$\frac{\text{Total no. of puparia}}{\text{Total no. of berries}} \times 100.$$

*Results and Discussion*

Table II shows that either 2 or 3 post-blossom applications of DDT at  $\frac{1}{2}$  lb. per 100 gal. of water reduced the infestation on red currant and gooseberry; and that the first post-blossom treatment, at  $\frac{1}{2}$  lb., did not appear to enhance control. A third post-blossom spray may increase the DDT residue on the harvested fruit to or near 7 p.p.m. (Allen *et al.*, 1950).

Table II  
RESULTS OF THE APPLICATION OF DDT SPRAYS  
TO CONTROL THE CURRANT FRUIT FLY IN 1947

<i>Fruit</i>	<i>No. sprays (post-blossom)</i>	<i>Rainfall first spray to harvest (inches)</i>	<i>Total puparia from three <math>\frac{1}{2}</math> pint samples</i>	<i>Percentage infestation</i>
Red currant	3	4.68	10	0.5
	3	4.68	9	0.5
	2	2.42	5	0.3
	Check	4.68	243	13.6
Gooseberry	3	4.68	10	3.0
	3	4.68	7	4.3
	Check	2.42	65	29.2

Table III shows that 2 post-blossom DDT applications, with or without a pre-blossom DDT spray, reduced the infestation on red currant. The pre-blossom spray, even at 2 lb. of DDT in 100 gal. of water, did not appear to enhance control. The 2 post-blossom applications of methoxychlor gave results comparable to those of DDT.

Table III  
RESULTS OF APPLICATION OF DDT AND METHOXYCHLOR  
TO RED CURRANT TO CONTROL THE CURRANT FRUIT FLY IN 1950\*

<i>Insecticide</i>	<i>No. of sprays</i>		<i>Total puparia from three 1-pint samples</i>	<i>Percentage infestation</i>
	<i>Pre-blossom</i>	<i>Post-blossom</i>		
Treatment 1			200	6.6
DDT	1	2	305	8.8
Treatment 2			91	2.1
DDT		2	131	3.5
Treatment 3			198	5.3
Methoxychlor		2	86	1.9
Check			708	26.9
Check			612	14.2

\*Rainfall from first spray to harvest was 8.36 inches.

- Table IV shows that 2 post-blossom sprays of either DDT or methoxychlor reduced the infestation on red currant.

Table IV

RESULTS OF APPLICATION OF DDT AND METHOXYCHLOR  
TO RED CURRANT TO CONTROL THE CURRANT FRUIT FLY IN 1951\*

Insecticide	No. of post-blossom sprays	from three 1-pint samples Total puparia	Percentage infestation
Treatment 1		24	0.7
DDT	2	119	4.8
Treatment 2		27	0.9
Methoxychlor	2	43	1.5
Check		1,517	48.8
Check		1,671	60.0

Tables I, II, III, and IV show that 2 post-blossom applications of a spray containing  $\frac{1}{2}$  lb. of actual DDT in 100 gal. of water, applied till the foliage drips, will effectively control the adult of the currant fruit fly in cages and in the field. This treatment has been recommended. The first spray is applied when 80 per cent of the fruit has set and the second 10 days later (Allen and Bird, 1948; Andison *et al.*, 1951).

Tables III and IV show that methoxychlor used in 2 post-blossom applications of a spray containing  $\frac{1}{2}$  lb. in 100 gal. of water is equally effective.

Rainfall did not appear to reduce the efficacy of the DDT residue.

The application of DDT or methoxychlor sprays to currant and gooseberry for the control of the currant fruit fly has resulted in an increase of mites, *Eotetranychus* spp., and the diseases anthracnose and mildew. The combined effects of the mites and diseases caused severe defoliation on some of the plots. This problem is being investigated.

## SUMMARY

1. A laboratory experiment on the control of the currant fruit fly, *Epochra canadensis* Loew, showed that a single application of DDT at  $\frac{1}{8}$  or  $\frac{1}{4}$  lb. of actual toxicant per 100 gal. of water was inadequate.

2. A pre-blossom application of as much as 2 lb. of actual DDT per 100 gal. of water did not improve the control.

3. The DDT residue remained effective on the foliage for 2 to 3 weeks after application. Rainfall apparently had no effect on control by spray residues.

4. Two post-blossom applications at  $\frac{1}{2}$  lb. of DDT or of methoxychlor per 100 gal. of water, applied to point of run-off, will effectively control the adults.

5. The application of DDT or methoxychlor sprays to currant and gooseberry has been followed by an increase in mites, anthracnose, and mildew, the combined effect being extensive defoliation.

\*Rainfall from first spray to harvest was 1.54 inches.



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## ANNOTATED LIST OF PREDATORS OF TETRANYCHID MITES IN MANITOBA<sup>1</sup>

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The author studied predators of tetranychid mites in 1950 and 1951 at Brandon and Morden. Before this study there was no detailed information concerning either the species of mites present in Manitoba or their predators. Infestations of mites are occasionally a problem on small fruits such as currant and raspberry, and on ornamental trees, shrubs, and flowers. Because large-scale chemical control, similar to that in commercial orchards elsewhere in Canada, has not been necessary in Manitoba, an opportunity was presented to study the mites and their predators in an environment free from the disturbing effects of a spray program.

Three species of Tetranychidae were found. On the basis of collection records, the predominant mite species is *Eotetranychus mcdanieli* (McG.) [*Tetranychus mcdanieli* McG.]. *E. mcdanieli* was found on 22 different host plants, both wild and cultivated trees, shrubs, and flowers. A second species, collected on apple at Morden, is *Eotetranychus pacificus* (McG.) [*Tetranychus pacificus* McG.]. The clover mite, *Bryobia praetiosa* Koch, on rare occasions attracts attention by invading a house.

Except *Hyaliodes vitripennis* (Say), all predators were either reared or collected by the writer. They were reared in small glass shell vials, stoppered with moistened absorbent cotton. This method was satisfactory for all predators except the Syrphidae and the Neuroptera.

The Acarina were determined by Dr. H. H. J. Nesbitt, Carleton College, Ottawa, and the Thysanoptera by Miss Kellie O'Neill, Bureau of Entomology and Plant Quarantine, Washington, D.C. Determinations were made by officers of the Division of Entomology, Ottawa, as follows: Coleoptera, Mr. W. J. Brown; Hemiptera, Dr. B. P. Beirne; Neuroptera, Dr. E. G. Munroe; Diptera, Messrs. J. F. McAlpine and J. R. Vockeroth.

### COLEOPTERA COCCINELLIDAE

#### 1. *Stethorus punctum* (Lec.)

Adults, pupae, larvae, and eggs found on mite-infested leaves, Brandon and Morden, 1949, 1950, 1951.

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Adults overwinter in trash cover or other protected habitats, and emerge in May. There are at least two generations per year, and because of the long life of some adults there is much overlapping of generations. Oviposition ceases about September 1, but larvae, pupae, and adults can be found as long as the host mites are available (in 1951 until September 22).

Both adults and larvae are predacious on all stages of the mites. This species is probably the most important predator of mites in Manitoba. Known predators of larvae of *S. punctum* are *Orius insidiosus* (Say), *Anthocoris musculus* (Say), and larvae of *Chrysopa* spp.

2. *Adalia bipunctata* (L.)

Adults and first-instar larvae occasionally found feeding on mites, Brandon and Morden, 1950, 1951.

Larvae could not be reared on mites. Various species of aphids are the main food of this species, and the number of mites destroyed by it is very small. This is probably true of several other large lady beetles. All the Coccinellidae noted by Lord (1949) as feeding on the European red mite are present in Manitoba.

PHALACRIDAE

3. *Stilbus probatus* Casey

One larva found on a mite-infested leaf, Brandon, June 24, 1951.

This was the only larva of this species found during the study. It was given fresh mites daily, and was observed feeding on the nymphs and adults. The larva pupated on July 6, and the adult emerged on July 10. This is believed to be a new record for food habits of the larvae of this species.

HEMIPTERA

ANTHOCORIDAE

4. *Orius insidiosus* (Say)

Nymphs and adults present on mite-infested leaves late May to early September, Brandon and Morden, 1950, 1951.

Both nymphs and adults are predacious on mites. This species is the most abundant of the predacious bugs in Manitoba. Nymphs were easily reared to adults on mites, but under natural conditions this predator is probably a general feeder.

5. *Anthocoris musculus* (Say)

Nymphs and adults present on mite-infested leaves June to early September, Brandon and Morden, 1950, 1951.

Both nymphs and adults are predacious on mites. Nymphs were easily reared to adults on mites, but under natural conditions this predator is probably a general feeder.

MIRIDAE

6. *Diaphnidia pellucida* Uhl.

Nymphs and adults found on mite-infested leaves, July and August, Brandon and Morden, 1950, 1951.

Both nymphs and adults are predacious, and nymphs were reared to adults on mites.

7. *Hyaliodes harti* Knight

Adults collected on mite-infested leaves, August, Brandon, 1950, 1951. Recorded by Lord (1949) as a predator of the European red mite.

8. *Hyaliodes vitripennis* (Say)

One specimen collected at Aweme, Sept. 4, 1929, and now in the collection at the Field Crop Insect Laboratory, Brandon. Recorded by Gilliatt (1935) as a predator of the European red mite.

9. *Plagiognathus obscurus* (Uhl.)

Adults collected on mite-infested leaves, June, July, and August, Brandon, 1950, 1951. Recorded by Gilliatt (1935) as a predator of the European red mite.

## NABIDAE

10. *Nabis ferus* (L.)

Nymphs and adults collected on mite-infested leaves, August, Brandon, 1951.

Both nymphs and adults are predacious. Nymphs were reared to adults on mites. This species is better known as a predator on larger noxious insects in orchards and vegetable gardens. As far as is known, it has not previously been recorded as a predator of tetranychid mites.

## THYSANOPTERA

## PHLAEOTHIRIPIDAE

11. *Haplothrips faurei* Hood

Nymphs and adults present on mite-infested leaves, May to September, Brandon and Morden, 1950, 1951.

Nymphs were reared to adults on mites. This is an important predator, very abundant, and present throughout the season.

## THRIPIDAE

12. *Scolothrips sexmaculatus* (Perg.)

Nymphs and adults present on mite-infested leaves, May to September, Brandon and Morden, 1950, 1951.

Nymphs were reared to adults on mites. This is an important predator, though not so commonly found as *H. faurei*. It is present throughout the season, but is most abundant during July and August.

## AELOTHRIPIDAE

13. *Aelothrips melaleucus* Hal.

One specimen collected on mite-infested leaves, August, Morden, 1950. Recorded by Putman (1942) as a predator of mites.

## DIPTERA

## CECIDOMYIIDAE

14. *Feltiella* sp.

Adults, pupae, larvae, and eggs found on mite-infested leaves, May to September, Brandon, 1950, 1951. Predacious cecidomyiid maggots from Morden, though not reared, are probably of the same species.

The larva is an important predator; observations indicate that tetranychid eggs, nymphs and adults, are its sole source of feed. The durations of both egg and larval stages are exceedingly short, about 3 and 6 days, respectively. The last-instar maggot spins a whitish, silken cocoon on the undersurface of the leaf, usually at the junction of two leaf veins. The average duration of the pupal stage for 28 pupae reared in the laboratory at 80° F. was 5.7 days. At the end of the pupal period, the pupa emerges from the cocoon. The pupal skin is shed, and remains on the leaf near the empty cocoon after the adult has emerged. Because of the very rapid



development and of the presence of this predator during the entire season, there may be several generations per year. It is believed to over-winter as a pupa in the cocoon. The known habits of this species are similar to those given by McGregor and McDonough (1917) for two predacious species of Cecidomyiidae.

#### SYRPHIDAE

15. *Toxomerus geminatus* (Say)

Larvae present on mite-infested leaves, July and August, Brandon, 1950, 1951.

At least two species of predacious syrphids were noted feeding on mites. The larvae appear to prefer aphids, but will readily devour any mites encountered. Cotton-stoppered vials were unsuitable for rearing the larvae. One adult of the above species was obtained by rearing, the larva pupating on July 26, and the adult emerging on July 31.

#### NEUROPTERA

Chrysopid eggs were often found attached to mite-infested leaves or nearby twigs. Several species of chrysopid or hemerobiid larvae were found, but none in large numbers. The few larvae that were fed on mites were voracious feeders. Attempts to rear them to adult form in cotton-stoppered vials were unsuccessful. The following species were collected as adults by sweeping mite-infested currant bushes.

#### CHRYSOPIDAE

16. *Chrysopa plorabunda*, var. *californica* Coq.

Adults collected, August, Brandon and Morden, 1951.

17. *Chrysopa harrisii*, var. *externa* Hag.

One adult collected, August, Brandon, 1951.

18. *Chrysopa chi* Fitch

Adults collected, August, Brandon and Morden, 1951. Apparently the most abundant species of *Chrysopa* in southern Manitoba.

#### HEMEROBIIDAE

19. *Hemerobius simulans* Wlk.

One adult collected, August, Brandon, 1951.

20. *Hemerobius stigmaterus* Fitch

Adults collected, August, Brandon, 1951.

#### ACARINA

#### LAELAPTIDAE

21. *Typhlodromus fallacis* (Garm.)

Adults, nymphs, and eggs present on mite-infested leaves, early May to September, Brandon, 1950, 1951.

Both nymphs and adults are predacious on all forms of the host mites. This predator is most abundant from early May to late June, and during that time, in both 1950 and 1951, it almost completely destroyed infestations of *E. mcdanieli* in two plantings in Brandon. After June *T. fallacis* appears to be present in reduced numbers, but is still of sufficient importance that it is second only to *S. punctum* in value as a predator.

22. *Typhlodromus longipilus* Nes.

Adults, nymphs, and eggs present on mite-infested leaves, August, Morden, 1951.

## - ANYSTIDAE

23. *Anystis agilis* Banks

Adults present on mite-infested leaves, July and August, Brandon and Morden, 1950, 1951.

This predator readily feeds on the host mites when confined with them in rearing containers. In the field it is abundant for a short period during the hottest part of the season. The adults are very active, and appear to wander aimlessly over large areas of plant growth in their search for food.

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## STUDIES ON THE TOXICITY OF WARBLE SPRAY MIXTURES TO CATTLE, SHEEP AND SWINE

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## INTRODUCTION

The Ontario Warble Fly Committee, from the commencement of its activities in 1947, has been confronted annually with decisions to make regarding causes of occasional deaths in herds of cattle coincident with, or shortly after warble treatments. Such problems arise when owners feel they have justification for making claims for losses against the township councils or insurance companies involved. The fact is overlooked that sickness, abortions and deaths are bound to occur amongst a population of hundreds of thousands of animals, regardless of a warble fly control programme.

In making decisions on the causes of casualties coincident with treatment, pathologists have had no definite guide such as specific lesions or methods of analysis which would indicate rotenone poisoning. The policy has been, in conducting most investigations, to search for other causes of death, such as bacterial infections or specific lesions of common diseases and thus to rule out the likelihood of rotenone being the primary cause or factor. Unfortunately, days and sometimes weeks elapse before individual cases are brought to the attention of pathologists, who, under such circumstances cannot conduct satisfactory autopsies.

In the spring of 1950, three reports were received regarding pigs becoming ill or dying following the spraying of cattle on the same premises. In the initial instance swine were reported to have quenched their thirst on spray that had run off the backs of cattle and had formed

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shallow puddles in the gutters or on the barn floors. In the second case, where casualties occurred, the mechanical water supply system was reported to have become contaminated with spray in the cattle section of the barn and thence to have been carried to the pig pens. In the third instance a pail of spray material was mistaken for swill and actually fed to the pigs. As the evidence in two cases at least was entirely circumstantial a test was conducted to obtain data as to whether or not the warble spray mixture was actually toxic to pigs. Two healthy animals weighing approximately 75 pounds each were given three litres of standard spray mixture in a trough. They drank freely of the mixture and died within fifteen minutes. This observation suggested that rotenone might be more toxic to pigs and possibly ruminants than was generally accepted to be the case. In the past derris and cubé powders have been looked on by many as relatively innocuous when taken by mouth. Under the circumstances the committee deemed it advisable to investigate further the possibilities of toxicity, particularly in view of the fact that over 500,000 treatments were being applied annually to cattle in Ontario.

The active principle of warble spray and hand dressing mixtures is 5% rotenone or its equivalent in derris or cubé powder. For the spray method of treatment  $7\frac{1}{2}$  lbs. of derris or cubé are mixed in 80 Imperial gallons of water. Wettable sulphur is sometimes included. Sprays are applied at 400 lbs. pressure, one half to one gallon is used on each animal treated. The concentrated hand dressing mixture, 1 lb. of the powder to 1 Imperial gallon of water, is applied with scrubbing brushes in sufficient quantities to thoroughly wet the backs of the cattle receiving treatment.

## METHODS AND MATERIALS

### *Experimental Animals*

Cattle used in the main experiments, in 1951, were seven grade animals including a heifer, steer, and five cows, one of which was pregnant. The weights of these animals ranged from 341 to 723 lbs. One pure bred Holstein cow and her newly born calf were used also. All animals, except the calf were kept under observation for two weeks before being treated to ensure that they were in normal health. Swine used were twenty-three pure bred Yorkshire pigs. Suckling pigs treated ranged in weight from 18 to 30 lbs. and weaned pigs from 68 to 105 lbs. A test was conducted on only one adult ewe to obtain an indication of the possible effects of rotenone on sheep. All pigs, save a few showing early evidence of rhinitis and the ewe appeared in normal health prior to treatments. Controls were used for all tests and consisted of animals on the same premises in similar environment and on identical diets.

### *Rotenone Preparations*

The preparations used in all the experiments reported were (i) a standard commercial warble spray powder mixture, containing wettable sulphur; and, (ii) cubé powder alone as used in (i). Both preparations were obtained freshly from the manufacturers.

Independent analyses revealed that the spray mixture contained 3.8 per cent and the cubé powder 4.5 per cent rotenone.

Results in this paper are based on rotenone content as a level of determination. It is recognized however that toxicity of cubé may be due, in part, to other rotenoids.

### *Methods of Administration*

Animals were administered internally suspensions of warble spray powder or cubé in water or milk either by allowing them to drink *ad libitum*, or by means of stomach tubes.

External application of sprays upon animals or their food was applied with standard spraying equipment at 400 lbs. pressure through a No. 5 disc.



## EXPERIMENT NO. 1 (Cattle)

(See Table I for summary of results.)

This experiment was designed to ascertain what quantities, if any, of standard spray mixture thirsty cattle would consume voluntarily. At the same time it was anticipated that an indication would be obtained of the probable toxic dose of spray mixture when taken internally.

*Results*

(a) Cattle deprived of water overnight drank standard spray mixture *ad libitum* in varying quantities and survived.

(b) An individual animal (No. 1) survived the drinking of 19 litres (4.0 gallons) (rotenone 20 mg./kg.) standard spray mixture in a period of 24 hours, without showing ill effects other than that of inappetence for the following 48 hours.

(c) The same animal survived the drinking of 33 litres (7.26 gallons) (rotenone 34 mg./kg.) consumed in the period of one week.

*Conclusions*

It is concluded, on the basis of the limited numbers of animals used, that:—

(a) Cattle will not exhibit symptoms of poisoning other than inappetence with quantities of spray mixture with a rotenone content of 20 mg./kg. if taken over a period of 24 hours or longer.

(b) Cattle are not likely to drink fatal doses of standard spray mixture under the usual conditions of spraying.

TABLE I

RESULTS OF ADMINISTERING STANDARD SPRAY MIXTURE TO CATTLE IN DAILY OR FREQUENTLY REPEATED DOSES FOR A PERIOD OF ONE WEEK

<i>Experimental Animal Number</i>	<i>Body Weight</i>	<i>Dosage Standard Spray Mixture</i>	<i>Dosage mg./kg. Rotenone</i>	<i>Effect</i>	<i>Remarks</i>
3	723 lbs. (328 kg.)	14 litres (3.08 gallons)	15 x	Survived	2 litres (2 mg./kg.) daily for 7 days.
2	760 lbs. (345 kg.)	28 litres (6.16 gallons)	29 x	Survived	4 litres (4 mg./kg.) daily for 7 days.
1	750 lbs. (340 kg.)	33 litres (7.26 gallons)	34 x	Survived	<i>Ad libitum</i> in 1 days. (Consumed on day 1, 6 litres; day 2, 13 litres; days 3 and 4 nil, (inappetence); day 5, 2 litres; day 6, 3 litres; day 7, 9 litres.)

## EXPERIMENT NO. 2 (Cattle)

(See Table II for Summary of Results)

This experiment was conducted to obtain an indication of the toxic or fatal doses of standard spray mixture for cattle, and to ascertain in conjunction with other experiments, the symptoms and post-mortem lesions of spray mixture poisoning in these animals.

A cubé mixture, *per se* was tested to eliminate the possibility that wetting agents or ingredients other than rotenone were not involved in producing symptoms.

A five gallon (22.7 litres) drench of water was administered to one control animal to establish that symptoms did not develop from the mechanical action of volume of liquid used.

## Results

- (a) Animals survived doses of standard spray mixture up to 3 gallons (rotenone 18 mg./kg.).
- (b) Animals died from doses of 5 gallons of standard spray mixture and cubé in water (rotenone 25 mg./kg. and 28 mg./kg. respectively).
- (c) No symptoms were evidenced by an animal given 5 gallons of water as a control.

## Conclusions

- (a) The single toxic dose of standard spray mixture capable of producing the first noticeable indications of poisoning is in the vicinity of one gallon of spray mixture per 195 lbs. body weight (rotenone 18 mg./kg.).
- (b) The fatal dose of spray mixture for cattle is indicated to be in the proportion of one gallon to 145 lbs. body weight (rotenone 25 mg./kg.).
- (c) The range between the toxic non-fatal and fatal doses of rotenone for cattle appears to be small; i.e. 7 mg./kg.

TABLE II

RESULTS OF ADMINISTERING CATTLE STANDARD SPRAY MIXTURE OR  
CUBÉ MIXTURE *PER SE* IN SINGLE LARGE DOSES

Experimental Animal Number	Body Weight	Dosage	Dosage mg./kg. Rotenone	Preparation Used	Effect	Remarks
4	579 lbs. (263 kg.)	9.09 litres (2 gallons)	12 x	Standard spray mixture	Survived	No symptoms
5	585 lbs. (265 kg.)	13.64 litres (3 gallons)	18 x	"	"	Inappetence
3	723 lbs. (328 kg.)	22.73 litres (5 gallons)	25 x	"	Died	Survived 13 days
1 xx	750 lbs. (340 kg.)	22.73 litres (5 gallons)	28 x	Cubé and water	Died	Survived 6 days
2	760 lbs. (345 kg.)	22.73 litres (5 gallons)	not applicable	Water only	Survived	Control — no symptoms

x Recorded to nearest whole number.

xx Administered after recovery from previous dosage.

*EXPERIMENT NO. 3 (Cattle)*

To obtain information as to the degree to which hay contaminated with standard spray mixture might be harmful to cattle, two bales were spread out loosely and saturated with 12 gallons (54.6 litres) of the liquid at 400 lbs. pressure. This amount is far in excess of that which is likely to fall upon hay in barns during routine spraying. The treated hay was fed twice daily for six days to a heifer and steer weighing respectively 415 lbs. and 644 lbs. Both animals were lodged in the same loose box. On the first day their drinking water, grain ration and bedding were also saturated with spray.

*Results*

During the six days of feeding on the sprayed hay neither heifer nor steer developed any symptoms. On the seventh day they refused all food, but on the eighth day recovered their appetites and remained normal for the additional thirty days during which they were kept under observation.

*Conclusions*

It seems evident that hay, grain or drinking water contaminated by spray mixture presents no serious health hazards to cattle.

*EXPERIMENT NO. 4 (Cattle)*

\* A grade cow weighing 760 lbs. (345 kg.), in advanced pregnancy was administered 28 litres (6.16 gallons) rotenone 29 mg./kg.) over the course of seven days, to ascertain if drinking spray mixture could be a factor in causing abortion.

*Results*

A normal calf was born two months later. (See Table I, Experimental Animal No. 2 for details of daily dosage.)

*EXPERIMENT NO. 5 (Cattle)*

A Holstein cow and her newly born calf were saturated daily on five successive days with spray mixture applied at 400 lbs. pressure to ascertain if calves could be poisoned by nursing on sprayed dams, or by licking the recently sprayed udder or hair. This experiment was done in February in an unheated barn. At the conclusion of the spraying test the calf was administered one litre of spray mixture by drench.

*Results*

The repeated daily sprayings produced no ill effects on either calf or dam. The administration of the litre drench of spray mixture was followed by a few hours of inappetence, after which the calf nursed normally and remained healthy.

*EXPERIMENT NO. 6 (Cattle)*

To test the palatability of the stronger hand-dressing mixture containing one pound of the powder to a gallon of water, a bucketful was presented in turn to eight head of cattle. All these animals had been deprived of water overnight and had consumed their dry hay and grain rations the previous evening and on morning of the test.

*Results*

Some animals dipped their muzzles into the bucket of hand-dressing mixture, but all eight refused to drink any of it.

*Conclusions*

It seems evident that cattle, unless suffering from depraved appetites, will not consume hand-dressing mixture to which they might gain access.



## EXPERIMENT NO. 7 (Sheep)

To obtain an indication of the possible toxic effect of spray mixture taken internally by sheep, an adult ewe was drenched with half a gallon of the preparation.

*Results*

For three days after drenching the animal refused to eat, drink, ruminate or move, after which she recovered her appetite and returned to normal health.

*Conclusions*

It appears that the spray mixture taken in sufficient quantities might be dangerous to sheep. It is highly improbable however that sheep would voluntarily ingest a harmful quantity.

SYMPTOMS, COURSE AND POST-MORTEM FINDINGS OF ROTENONE POISONING  
IN CATTLE

From the collective experiments recorded above observations were made on the symptoms, course and post-mortem changes in animals which received sufficiently large doses of standard spray or cubé mixtures to produce toxic effects. In addition, one cow weighing 650 lbs. (295 kg.), was administered, in one dose, 30 oz. of standard powder in five gallons (22.7 litres) of water, the equivalent of 20 gallons of spray (rotenone 110 mg./kg.) mixture in order to produce, if possible, specific lesions of rotenone poisoning in cattle. This animal is not included in Table II because the concentration of rotenone used was not that of the standard spray mixture.

In all cases symptoms of ill effect were primarily inappetence, followed by cessation of borborygmus and rumination, a reluctance to move and variable degrees of dyspnoea, inclining toward abdominal respiration. Animals which received 18 mg./kg. of rotenone or less, in single doses, recovered from these symptoms within 48 hours.

In all three fatal cases (*vide* Table II and the animal mentioned above) the initial symptoms just described were followed by an increased reluctance to rise, intermittent groaning and increased dyspnoea. Pulses became rapid, feeble and finally imperceptible. In one animal a persistent clear mucoid discharge from the nostrils was noted. In all, faeces were liquid, and continued to flow intermittently without effort, until the days of death. Prior to the latter event temperatures became subnormal and extremities cold.

The course of illness in each fatal case was six days for No. 1 animal (28 mg./kg. rotenone); 13 days for No. 3 animal (25 mg./kg. rotenone); and 14 days for the animal which received 30 ounces of spray powder (110 mg./kg. rotenone). (The life of this animal may have been prolonged as treatment was given in an attempt to counteract the effect of the rotenone). In no case did cattle, like pigs, develop convulsive symptoms of poisoning or any noticeable evidence of paralysis of the hind limbs.

The examination of internal organs revealed the rumena partially filled with semi-liquid contents; the omasa packed with relatively dry ingesta; mild inflammation of the abomasa; areas of ecchymosis in the duodena and ilea fusing, in the animal which received the 110 mg./kg. of rotenone, to form a generalized sub-acute catarrhal enteritis in the last 20 feet of the ileum.

Colons, in the gross, showed little change, but some round cell infiltration in the tunica propria and hyperplasia of the lymph follicles were observed in sections. The spleens were acutely congested and had haemorrhaged.

Liver degeneration consisted of cloudy swelling. In one organ there were a few focal areas of necrosis into which round cells had infiltrated.

Lungs showed variable changes consisting of engorged capillaries, collapsed alveoli, some emphysema and oedema and bronchioles containing catarrhal exudates.

Kidney lesions showed no consistent changes. In the first case great swelling of cells preceded or accompanied necrosis of many cells in the proximal convoluted tubules; numbers of tubules contained hyaline casts and round cells had infiltrated the interstitial tissue diffusely. In the second case renal lesions were limited to cloudy swelling and sub-capsular infiltration of eosinophiles, while in the third case degeneration of the proximal convoluted tubules and congestion of intertubular capillaries comprised the changes.

In the animal which received the large dose of rotenone (110 mg./kg.) early degenerative changes were present in the myocardium. In another animal heart lesions consisted of haemorrhages under the endocardium which extended into the myocardium.

Lesions of the central nervous systems were not visible in the gross. In the spinal cords the neurones of both the anterior and posterior horns contained cells which had retained their angularity and many of their granules, but in which the nuclei were indistinct or absent. Neurones in one instance showed a very unusual change in morphology — cells being divided into three or four fragments without nuclei or Nissl granules. Microscopic changes in the cerebella included neurones in the molecular layers showing early degeneration, and elsewhere Purkinje cells characterized by loss of granules and eccentric nuclei.

It appears probable that the experimental deaths in cattle are caused by paralysis of the smooth muscle of the alimentary canal, absorption of intestinal toxins, and interference with respiratory and heart actions in association with degenerative changes of the central nervous system. It is also possible that modifications in the micro-fauna and micro-flora of the rumen may have had an effect on rumination.

#### *ROTENONE POISONING IN SWINE*

Incidental to the studies of rotenone tolerance in cattle, tests were made to ascertain what effects, if any, similar spray mixtures might have upon pigs. This phase of the investigation was initiated because, as already stated, casualties occurred amongst pigs in 1950 on farms following the spraying of cattle for grubs.

The first casual tests were conducted in 1950 on two suckling pigs to which were administered individually by stomach tube, 30 cc. of standard spray mixture, without ill effect. The possibility was considered that the sow's milk present in the nursing pigs' alimentary canals might have given them protection.

As noted in the introduction two weaned pigs, weighing approximately seventy-five pounds, were offered three litres of spray mixture in a trough. They drank readily a considerable portion of the material and within fifteen minutes were both dead. Their litter mates in an adjoining pen remained normal.

To obtain more complete data varying doses of spray were administered to pigs either in its standard form or with the addition of milk. As with cattle these studies were carried out in January and February 1951.

#### *EXPERIMENT NO. 8 (Swine)*

(See Table III for Summary of Results)

Eight pigs, varying in weight from 18½ lbs. to 105 lbs. were administered standard spray mixture in amounts varying from 62 to 500 cc.

#### *Results*

Animals which received respectively 22.2, 6.5, 3.7, mg./kg. rotenone in the spray mixture died. The 22.2 and 6.5 mg./kg. doses were administered to suckling pigs, and the 3.7 mg./kg. dose to a weaned pig. Three weaned pigs received respectively, 2.0, 1.8 and 1.6 mg./kg. rotenone. That receiving 2.0 mg./kg. died, while the two others developed symptoms of poisoning but recovered. Two weaned pigs administered respectively, 1.1 and 0.5 mg./kg. rotenone each showed no symptoms and survived.

*Conclusions* — Combined with Experiment 9.

TABLE III

## RESULTS OF ADMINISTERING STANDARD SPRAY MIXTURE TO SUCKLING AND WEANED PIGS

<i>Experi- mental Animal Number</i>	<i>Body Weight</i>	<i>Dosage cc.</i>	<i>Dosage mg./kg. Rotenone</i>	<i>Effect</i>	<i>Remarks</i>
1	18½ lbs. (8.4 kg.)	500	22.2	Died	Suckling pig.
7	30 lbs. (13.6 kg.)	250	6.5	Died	Suckling pig.
8	105 lbs. (47.6 kg.)	500	3.7	Died	Weaned pig.
10	100 lbs. (45.3 kg.)	250	2.0	Died	Weaned pig.
11	93 lbs. (42.2 kg.)	188	1.6	Survived	Weaned pig.
12	93 lbs. (42.2 kg.)	218	1.8	Survived	Weaned pig.
12 x	93 lbs. (42.2 kg.)	125	1.1	Survived	Weaned pig.
11 x	93 lbs. (42.2 kg.)	62	0.5	Survived	Weaned pig.

## EXPERIMENT NO. 9 (Swine)

(See Table IV for Summary of Results)

To ascertain whether or not it was the rotenone content of the spray mixture which caused symptoms, apart from wetting agents, four pigs were administered cubé and water only.

*Results*

Those animals which received respectively 10.8, 9.5 and 6.8 mg./kg. rotenone died. One which received 3.7 mg./kg. rotenone manifested severe symptoms of poisoning but recovered.

TABLE IV

## RESULT OF ADMINISTERING CUBÉ POWDER IN WATER TO SUCKLING AND WEANED PIGS

<i>Experi- mental Animal Number</i>	<i>Body Weight</i>	<i>Dosage cc.</i>	<i>Dosage mg./kg. Rotenone</i>	<i>Effect</i>	<i>Remarks</i>
2	21½ lbs. (9.7 kg.)	250	10.8	Died	Suckling pig.
4	98 lbs. (44.4 kg.)	1000	9.5	Died	Weaned pig.
6	68 lbs. (30.8 kg.)	500	6.8	Died	Weaned pig.
9	93 lbs. (42.2 kg.)	375	3.7	Survived	Weaned pig.

x Administered after recovery from previous dosage.



### *Conclusions* (Experiments 8 and 9)

(a) Suckling and weaned pigs are highly susceptible to poisoning by relatively small quantities of rotenone. The ingestion of a very small quantity of spray mixture, even as little as 250 cc. for a 100 lb. pig, is fatal.

(b) The rotenone content of the spray mixture is the toxic factor. The presence of wetting agents may increase the absorption of rotenone. Note survival of animal No. 9, Table IV, after a dosage of 3.7 mg./kg. administered as cubé powder alone in water.

(c) The minimum lethal dose of rotenone in standard spray mixture for pigs appears to be approximately 2 mg./kg.

### *EXPERIMENT NO. 10* (Swine)

In an attempt to verify the indication that milk might be antidotal in rotenone poisoning, two suckling pigs, with empty stomachs, were administered each 250 cc. of fresh cow's milk containing respectively 8.5 mg./kg. rotenone in standard spray mixture and 10.1 mg./kg. rotenone in cubé.

### *Results*

Both pigs developed symptoms of poisoning but recovered.

### *Conclusions*

Fresh cow's milk, administered with rotenone, at approximately four and five times the minimum lethal dose indicated in Experiment No. 8 appears to give marked protection.

### *EXPERIMENT NO. 11* (Swine)

In view of the great susceptibility of swine to small amounts of rotenone taken internally, a sow with a nursing litter of 11 pigs, their bedding and walls of the pen were saturated with spray mixture applied at 400 lbs. pressure. This experiment was done to learn whether or not any health hazards existed to swine through the possible absorption of rotenone through the skin, or, in the case of very young pigs, if they could obtain sufficient amounts of the poison from the residue which might be left on the sows' udders.

### *Results*

Neither sow nor litter manifested any symptoms of rotenone poisoning during the week following treatment for which time they were kept under observation.

### *Conclusions*

It appears unlikely that spray mixture applied externally to pigs presents any direct health hazard. However, the hazard through ingestion as indicated in the preceding experiment is so great that the spray mixture should not be used near pigs.

### *EXPERIMENT NO. 12* (Swine)

During the course of the above experiments the opportunity was taken to feed pigs the muscle, heart, intestine, liver, kidney, brain and spinal cord tissues of cattle which had died of rotenone poisoning. The object of this experiment was to demonstrate whether or not the flesh of animals, particularly of beef cattle which had been sprayed for warbles, presented any public health problems.

Pigs were selected upon which to make the tests on account of their marked susceptibility to rotenone poisoning. Two animals weighing approximately 150 lbs. were deprived of all food other than the flesh of those cows which had succumbed to, respectively 28 and 110 mg./kg. rotenone. Because of the wasting and scattering of portions of the cattle tissues no accurate weights of the amounts consumed were recorded. The pigs, however, were observed eating the tissues and each consumed several pounds.

### *Results*

No visible ill effects followed the ingestion of tissues from experimentally poisoned cattle.

### *Conclusions*

It appears that the spraying of cattle and the subsequent consumption of their flesh, is most unlikely to cause any harm to man.

## SYMPTOMS, COURSE AND POST-MORTEM FINDINGS OF ROTENONE POISONING IN PIGS

Observations on the effects of rotenone upon pigs revealed relatively constant symptoms of poisoning. Primary actions in animals, whether they ultimately survived or died, were similar. These symptoms commenced with restless movements associated with occasional grunting. Usually within half an hour from the onset, animals which had received 2.0 mg./kg. rotenone or more, vomited or attempted vomition, ground their teeth and commenced profuse salivation.

The second stage of symptoms involved inco-ordination of movement, manifested by staggering gaits and proceeding rapidly to apparent paralysis of the hind limbs. At this point pigs invariably assumed a sitting position, attempted to rise but almost immediately collapsed, lying on their sides.

Constant symptoms from the stage of collapse, except in the case of those pigs which recovered, were dyspnoea, increased pulse rate, evidence of pain, negative reflexes and progressive decrease in body temperature from normal ( $102.2^{\circ}\text{F}$ ) to a sub-normal temperature of  $96^{\circ}\text{--}98^{\circ}\text{F}$ . This chilling was invariably associated with progressive cooling of the body extremities (feet, ears, tail) which, with markedly decreased rate of respiration, preceded death.

Variable symptoms noted included the development of "thumps", muscular tremors, transient erythema and the occasional passing of faeces and urine.

The course of poisoning in pigs developed and terminated with relative rapidity when compared with the effects of rotenone poisoning in cattle. Doses of 3.7 mg./kg. or more of rotenone killed pigs, usually, in from half an hour to four hours. In one case, however, a single suckling pig survived 10.8 mg./kg. of rotenone (in cubé and water) for 24 hours, whilst a weaned pig survived 9.5 mg./kg. rotenone in a similar preparation for only three quarters of an hour. A hundred pound pig which was administered 2.0 mg./kg. rotenone (in 250 cc. of spray mixture), succumbed in five hours. Pigs which developed symptoms of poisoning, but recovered, appeared normal between 24 and 48 hours after treatment. No complications developed, except in one instance, in which a non-fatal case of broncho-pneumonia followed treatment; this may or may not have been incidental to the administration of spray mixture internally.

The autopsy findings in swine, were variable, but in some respects similar to those encountered in cattle.

Stomach and intestines showed variable degrees of congestion, sometimes associated with moderate haemorrhages and desquamation of the epithelial cells from the tips of the villi.

The livers constantly manifested cloudy swelling, with a tendency of the cells immediately around the central veins to show increased depth of eosinophilic staining and marginal displacement of the nuclei. Congestion of the livers occurred occasionally.

Lungs showed evidence of congestion, occasional haemorrhage and broncho-pneumonia developing. (It is questionable whether the latter condition was caused by the treatment.)

Kidney lesions were limited to different degrees of degeneration in the epithelium of the convoluted tubules. Individual cells showed vacuolation, ragged borders and/or cloudy swelling.

Heart lesions, in one case, simulated those found in cattle, consisting of haemorrhages under the epicardium. Lesions of the central nervous systems observed were confined to some subependymal round cell infiltration in the cerebra.

#### SUMMARY

Results of a series of tests on toxicity of warble spray mixtures and cubé are outlined. Clinical and post-mortem systems are discussed.

Cubé spray mixtures used in warble control are toxic to cattle only in quantities which it is considered animals will not ingest in a control programme.

A similar degree of tolerance is apparently exhibited by sheep.

Cubé spray mixtures are highly toxic to swine. As small an amount as 250 cc. of standard spray mixture is a lethal dose for a 100 lb. pig. Indications are that both sows' and cows' milk are antidotal to rotenone poisoning in swine.

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## THE ANATOMY AND HISTOLOGY OF THE DIGESTIVE TRACT OF *HYLEMYA BRASSICAE* (BOUCHÉ) (DIPTERA: ANTHOMYIIDAE)

S. E. DIXON<sup>1</sup>

There is no account of the anatomy and histology of the digestive tract of any Anthomyiidae. However, other muscoid flies have been the object of detailed study, particularly the digestive system in *Calliphora* by Lowne (18) and Graham-Smith (16); the housefly by Hewitt (17); *Drosophila* by Strassburger E. (27), Strassburger M. (28), Miller (20) and others; *Glossina* by Minchin (21), Giles (14), Stuhlman (29) and Wigglesworth (31); and *Philaematomyia* by Patton and Cragg (22).

#### MATERIALS AND METHODS

Most of the flies used in this study were reared from puparia collected in the field.

Dissections were made of both living and fixed material. For gross staining of dissections, paracarmine in glycerine was used. This technique was especially valuable for studying the musculature of the gut.

Bouin's fixative proved most satisfactory using dioxane for dehydrating whole flies and ethyl alcohol for dissected guts. Sections were stained with Delafield's haematoxylin and eosin; some with Mallory's triple stain.

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## GENERAL

The alimentary canal includes the gut proper together with structures generally associated with it such as the salivary glands, labellar glands and malpighian tubules. While the malpighian tubules are not, strictly speaking, part of the digestive system, because of their intimate connection with the gut they are here considered for study.

The three regions of the gut typical of insects, stomodaeum (fore-gut), mesenteron (ventriculus or mid-gut) and proctodaeum (hind-gut) present distinct subdivisions.

## THE STOMODAEUM (FORE-GUT)

The true beginning of the alimentary canal is marked by a sphincter (about  $60\mu$  long and  $8-10\mu$  thick) surrounding the proximal dilatation of the oesophagus at its connection with the cibarium (pharynx) within the rostrum of the proboscis.

The oesophagus passes dorsally from the cibarium (pharynx) and curves sharply posteriorly toward the brain. The preganglionic portion of the oesophagus measures  $31-36\mu$  in diameter (except for its proximal dilatation where it joins the cibarium). Its tunic of circular muscles (no longitudinal muscles are seen) is uniformly  $3-4\mu$  thick. The epithelium is thrown into about ten folds longitudinally with an inner cuticular border  $1\mu$  thick. The epithelial cells are columnar in the sphincter region ( $13.5 \times 6\mu$ ) and become cuboidal ( $6 \times 6\mu$ ) toward the brain. A basement membrane is visible.

The ganglionic portion of the oesophagus is loosely attached to the brain by connective tissue, and is somewhat narrowed ( $22\mu$ ). This narrowing within the brain is found in *Philaematomyia* (22) and *Musca domestica* (17), but apparently not in *Calliphora* (16). It is not mentioned by Miller (20) for *Drosophila*. The muscular coat is of the same thickness as that of the preganglionic oesophagus ( $3-4\mu$ ), the epithelium is thinner ( $4\mu$ ) and the intima is about  $1\mu$  thick. Giles (14) states that the muscular and cuticular layers in *Stomoxys* are "barely perceptible".

The oesophagus passes from the brain through the occiput into the thorax below the aorta, and bifurcates as it approaches the "proventriculus". The oesophageal branch runs postero-dorsally into the "proventriculus". The crop duct continues posteriorly, ventral to the thoracic ventriculus and dorsal to the thoracic nerve ganglion, to the crop which lies within the first two, or sometimes three, abdominal segments.

In the region of the bifurcation the circular muscle layer thickens to about  $11.5\mu$  to form three sphincters, one anterior to the bifurcation and two posterior to it; of the latter one is on the crop duct and one on the oesophagus anterior to the hilus of the "proventriculus".

## THE CROP

At its anterior end the crop duct is a narrow tube about  $29-51\mu$  in diameter. The external circular muscle layer is  $2-3\mu$  thick. The epithelium appears to be thrown into a variable number (7-10) of longitudinal folds with a prominent cuticle. As it enters the abdomen the duct dilates to a large saccular, bilobed crop (Fig. 1). The crop when dissected in fresh specimens may be a flaccid, translucent, white sac. When turgid with food it is amber-brown and may measure  $1.26 \times 1.08 \times 0.9$  mm. When flaccid the crop wraps ventrally about the anterior region of the abdominal ventriculus. When full the crop displaces the ventriculus dorsally and slightly posteriorly. The bilobed appearance of the sac is somewhat obscured when it is fully distended with food. The crop epithelium consists of numerous, inwardly projecting, finger-like prolongations with small, round to oval nuclei ( $4.4-6\mu$  diameter). The epithelial folds are only apparent when the sac is either partly or entirely collapsed (Fig. 7). The crop musculature consists of a series of bands  $2-3\mu$  wide which encircle the crop transversely then anastomose freely along the median dorsal surface.

### THE "PROVENTRICULUS" OR CARDIA

The term "cardia" is adopted for *Drosophila* by Miller (20) who reasons that because it is, embryologically, a composite structure involving both fore-and mid-gut elements it is not a true proventriculus, which is a fore-gut structure of ectodermal origin. However, as the term "proventriculus" has become so fixed in the literature it is used here with quotation marks.

#### Gross Anatomy

The "proventriculus" (Figs. 1, 2) is a bulb-like swelling in the tract, 0.5-0.6 mm. posterior to the occipital foramen inclined forward at an angle of about  $45^\circ$  to the horizontal, measuring  $225-320\mu$  in diameter and  $190-225\mu$  long. It consists of an external wall which is the anterior end of the ventriculus distended to accommodate an internal "plug". The plug is shaped like a mushroom, the "stem" being a hollow tube. Surrounding the base of the stem region are two glandular swellings, the "annular pads" (32). The "proventriculus" has essentially the same form throughout the Muscidae (Wigglesworth 31).

#### Histology of the "Proventriculus"

The histology of the "proventriculus" is best studied in sagittal sections of the gut (Figs. 2, 3).

At the hilus, encircling the proventricular lumen entrance, is an annulus of muscle  $13\mu$  thick, the "basal ring muscle" of Graham-Smith (16).

The plug is of stomodaeal origin and its components are easily recognized by their chitinous intima. The central tubule of the plug is a continuation of the oesophagus and has the same general characteristics. The epithelial folding is similar to that of the oesophagus. The epithelial nuclei are small, not larger than  $4 \times 3\mu$ . The cuticular lining is less than  $1\mu$  thick and bears numerous spines. These spines may have led Lowne (18) to the inaccuracy of regarding the "proventriculus" as "a gizzard and nothing more" although he does not refer to their presence, if they exist, in the blowfly. The musculature of the epithelium of the plug lumen consists of an inner layer of longitudinal muscles and an outer layer of circular muscles which is relatively thick ( $5-8\mu$ ). These muscles are continuous with those on the exterior of the oesophagus and favour the theory that the plug is sphincter in action, as suggested by Wigglesworth (31), and not valvular as Hewitt (17) and Patton and Cragg (22) thought. The posterior orifice of the plug opens into the space between the wall of the "proventriculus" and the plug, opposite the orifice of the thoracic ventriculus. From its posterior orifice the true proventricular epithelium runs outward and downward, then with a smooth undulation runs slightly inward, then broadly outward. This broad flange then turns abruptly inward to form a rim finally downward to form a stem-like region for the mushroomed plug. No second flange is evident here as described by Graham-Smith (16) for *Calliphora*. In this respect *H. brassicae* is more like *Glossina* (31) and *Musca* (17).

This flange gives the plug its characteristic shape. The intima of the flange is less than  $1\mu$  thick. The epithelium consists of pale-staining cells which are cuboidal near the posterior orifice, gradually becoming columnar in the flange and along the reflected edge. Vacuoles are rare. A basement membrane was not seen. The bases of cells from either side of the flange appear to intermesh. Muscle strands run radially from the proventricular oesophagus toward the flange periphery to the epithelial cell bases. The epithelium of the flange is continuous in the stem region of the plug with the epithelium of the annular pads, but the line of demarcation is easily seen; the intima disappears and the annular pad cells stain more deeply (Figs. 2, 3). This region is the zone of junction (20). The flange epithelial nuclei are pale-staining, oval in outline and somewhat smaller than those of the pad cells.

The "annular pads" appear as a double ring about the base of the proventricular oesophagus (Figs. 2, 3). The inner, larger pad is separated from the proventricular stem by a cleft and follows, distally, the contour of the inner margin of the flange. The outer, smaller pad follows on its inner side the contour of the larger pad and its outer side appears to be contoured to receive the depending rim of the flange.

These pads in *Hylemya* show but slight difference from comparable structure figured for the Housefly (17), and *Calliphora* (18), (16). The pads and the "proventriculus" itself appear somewhat more modified in *H. brassicae* than in other forms; the outer pad appears larger in *Hylemya*. The "proventriculus" is noticeably modified in *Drosophila* (20) where there appears to be but one annular pad; the base of the ventricular wall evidently being the major secretory area.

The cells of the annular pads vary in length from low cuboidal to very tall columnar ( $90\mu$ ) in length. The cells rest on a basement membrane internal to the circular muscle layer of the proventricular wall. The pad cells narrow considerably toward their bases. The nuclei are relatively large, ( $11 \times 7\mu$ ) oval, and are as basal as their cell diameters will allow. The cytoplasm apparently varies with the physiological state of the cells. Globules and vacuoles may be seen. In Figure 3 it will be seen that the cell borders appear actively engaged in secreting the presubstance of the peritrophic membrane. At times the free surface may be hyaline or give the appearance of a well defined brush border.

Continuous with the outer, smaller, annular pad is the wall of the "proventriculus". The cells of the proventricular wall show the same characteristics attributed to them by Wigglesworth (31) in *Glossina*. The wall consists of a single layer of cuboidal cells, which are deep-staining and may exhibit vacuoles and globules like the cells of the annular pads. The free border may be hyaline, brush or appear actively engaged in secreting. Vacuoles are fewer than in the pads and a clear zone is sometimes seen. Graham-Smith (16) for *Calliphora* states "in the cubical cells of the vault (upper region of proventricular wall) the vacuoles are few and the clear zone small or absent".

The musculature on the exterior of the "proventriculus" consists of outer, widely separated, longitudinal fibres running posteriorly from the region of the hilus and an inner layer of closely packed circular muscles forming a sheet  $2\mu$  thick.

The *peritrophic membrane* is evident in the upper region of the proventriculus near the posterior orifice (Fig. 2). Following the membrane to the annular pad region one can see that it is composed of two sheets. Each sheet or lamina appears to arise between the clefts of the epithelial pads and the two give the appearance of being compressed into one in the space between the proventricular flange rim and the basal region of the proventricular wall. In favourable sections there can be seen the deep-staining secretion filling the space between the pads and the corresponding area of the flange, between the clefts and between the basal region of the proventricular wall and the flange. This is essentially the same as for *Glossina*, first described by Wigglesworth (31). Graham-Smith (16), however, could not see this secretion in *Calliphora*.

Histological evidence seems to support the interpretation that the function of the "proventriculus" is dual, first that it acts as a sphincter controlling the passage of food to and from the mid-gut, and secondly that it produces the peritrophic membrane. Regurgitation from the crop is probably controlled by a sphincter in the region of bifurcation of the oesophagus and also by the sphincter at the entrance to the oesophagus from the cibarium (2).

#### THE VENTRICULUS (MID-GUT)

##### Gross Anatomy

In the thorax the mid-gut or ventriculus passes, with a slight constriction, from the "proventriculus" in a straight course posteriorly, ventral to the aorta and dorsal to the crop duct. The well-developed wing muscles force the thoracic organs ventrally. The *thoracic ventriculus* usually has a somewhat variable diameter ( $150-160\mu$ ), and always shows surface corrugations.



The ventriculus narrows as it passes into the abdomen, curves dorsally and proceeds in the median line over the crop, below the aorta. When the crop is distended with food the ventriculus is displaced dorsally, almost touching the tergites. The ventriculus at the end of tergite 3 curves ventrally, anteriorly, dorsally and then posteriorly to form a clockwise coil (viewed from the left). At the hub of the coil it takes an abrupt turn right and immediately commences to "unwind" in a counterclockwise coil curving dorsally, anteriorly, ventrally, and finally posteriorly. The coiling or helix involves  $1\frac{1}{2}$  turns clockwise and  $1\frac{1}{2}$  turns counterclockwise.

The regions of the ventriculus (Fig. 1) within the abdomen have been variously named, but the nomenclature of Graham-Smith (16) seems to be most suitable. Lowne (18), Hewitt (17), Patton and Cragg (22), all use the term "intestine" in their descriptions, which seems unwise for mid-gut regions. Four regions are easily recognizable. The *abdominal ventriculus* is that region within the abdomen as far as the ventral curving in segment 3. From this curve to the end of the clockwise coil (viewed from the left) at the hub is the *proximal loop*. The counterclockwise coiling is the *helicoid* region. That region between the end of the coiling where the tube straightens as far as the origin of the malpighian tubules is the *post-helicoid* region. The helix in this form appears to be a constant feature. Though it has, at times, the appearance of being more "tightly wound", its general pattern is the same. Some of the biting muscoid flies (e.g. *Glossina* (31)) do not exhibit this helical arrangement to the mid-gut.

The abdominal ventriculus is the widest region of the mid-gut ( $195\mu$ ). At the commencement of the proximal loop the ventriculus begins to narrow until near the hub of the helix it measures no more than  $75\mu$ . The helicoid region more or less maintains this diameter, though occasional swellings are found. The post-helicoid region is the shortest region and may measure no more than  $180\mu$  in length.

The total length of the mid-gut in my specimens varied from 7.9 to 10.5 mm. The figures for the relative lengths of the various alimentary tract regions given by Graham-Smith (16) for various Muscids, apparently, are for larger specimens of each species. Hewitt (17) does state specifically that the gut length varies in the housefly. Miller (20) gives the unqualified length of 5 mm. for *Drosophila*, but the figures here presented represent not laboratory cultured flies of a known strain but wild types—hence possible greater variation.

### Histology of Ventriculus

The thoracic ventricular epithelium shows a transition from very low cells near the ventriculus to tall, attenuated columnar cells ranging in height from  $25-46\mu$  within .25 mm. of the "proventriculus" (Figs. 4, 9). Their nuclei are basal, round to oval with a prominent nucleolus. The cytoplasm may stain uniformly pink or at times be deep-staining and vacuolar. This difference in staining does not appear to be regional. Regenerative cells are not frequent. The musculature of the thoracic ventriculus consists of inner circular muscles arranged in bands  $3\mu$  thick,  $17-25\mu$  wide,  $10-15\mu$  apart consisting of about 10-12 fibres each. External to these run the longitudinal muscles, about 40 in number,  $4\mu$  wide,  $2.5\mu$  thick. Epithelial cells bulge between the latticework of muscles and account for the corrugated appearance of the thoracic ventriculus. This disappears in the abdomen.

The ventricular epithelium shows more differentiation within the abdomen. The cells of the abdominal ventriculus (Fig. 6) are tallest ( $62 \times 10\mu$ ) and those of the helicoid (Fig. 5) and post-helicoid (Fig. 6) regions are cuboidal and may be as small as  $7 \times 7\mu$ .

The cytoplasm of the abdominal ventricular cells rarely manifests the so-called "resting" stage. The cytoplasm appears highly vacuolar, rather spongy, without a distinct brush border. The cell bases are indented by circular muscles  $3-4\mu$  in diameter. Two or three such muscleless may indent the base of a single cell. Longitudinal muscles are present as scattered bands externally. Regenerative cells may appear between every second or third cell. These are identified by their small size, wedge shape, small nucleus and by their denser cytoplasm.

The cuboidal cells (Figs. 5, 6) usually show a brush border,  $1\mu$  thick, and are darker staining cells than those in the proximal loop or abdominal ventriculus. Though they may at times be vacuolar one does not see the budding of cytoplasm which is visible in the more proximal regions. Longitudinal muscle bands may be seen  $2-3\mu$  wide. Circular muscles are rare.

### THE HIND-GUT OR PROCTODAEUM

This is a variable portion of the digestive tract in Muscids. It consists of the anterior and posterior intestines separated by the region of the rectal valve.

The posterior intestine is divided into three parts (Fig. 1). It includes first the region between the rectal valve and the rectal pouch, which region we call the first part of the rectum and which is non-existent in *Drosophila* (20) where the rectal valve leads directly into the rectal pouch. The second region of the posterior intestine is the rectal pouch and posterior to it the third region called the anal rectum which ends with the anus.

A problem in nomenclature presents itself here. Since all Muscids do not possess a rectal valve (e.g. *Glossina* (31)) this cannot serve as a general landmark, and since there is no anterior or "first" part to the rectum in *Drosophila* (20) this presents a problem as well. Since the hind-gut so closely resembles *Calliphora* in its gross anatomy it might seem advisable to accept the nomenclature of Graham-Smith (16) who adopts that of Lowne (18) and Hewitt (17) but his terms cause some confusion in that his use of "hind-gut" is restricted to the particular portion of the proctodaeum anterior to the rectal valve, whereas "hind-gut" usually is used synonymously with proctodaeum. The terminology of Patton and Cragg (22) and Miller (20) might lead to confusion. The terminology of Graham-Smith (16) is therefore adopted substituting "anterior intestine" for "hind-gut".

### Gross Anatomy

The commencement of the hind-gut is marked by the entrance of the Malpighian tubules beneath tergite four. The *anterior intestine* describes a curve passing posteriorly, dorsally and finally anteriorly and to the left of centre (viewed dorsally). This (about  $630-700\mu$  long x  $120\mu$  diameter) constricts slightly at the entrance to the rectal valve which is identified as the slight swelling ( $465\mu$  long x  $270\mu$  diameter). From the rectal valve the *first part of the rectum* (posterior intestine) makes an abrupt turn anteriorly to the right then postero-dorsally in the shape of an inverted "U". (The gonads may, with development, displace the hind-gut forward and to the right, in which case the anterior intestine almost reaches the posterior tip of the ventricular loop of the mid-gut).

The first part of the rectum is about the same diameter as the anterior intestine and  $0.70$  to  $0.81$  mm. long. Its terminus is marked by the large *rectal pouch* which is usually beneath the last and the posterior part of the second to last, dorsally visible, tergite. It may be pyriform, wider at its anterior end and narrowing to the diameter of the anal rectum or appear as a regular swelling  $200\mu$  diameter x  $560\mu$  long. Whatever its shape it has four cone-shaped papillae visible through the membranous pouch wall; two on either side, one below the other (Fig. 1).

From the rectal pouch the gut passes posteriorly in a straight course as the anal rectum  $0.7$  mm. long.

### Histology of Hind-Gut

The *anterior intestine* is tubular in cross section ( $130\mu$ ). The epithelium is thrown into five or six longitudinal folds which may disappear when the tube is distended. The hind-gut epithelium is characterized like that of the stomodaeal by an intima which in this region is less than  $1\mu$  thick but clearly visible (Fig. 12). The epithelial cells are pale-staining and cuboidal, they may be as small as  $6 \times 6\mu$  near the entrance of the Malpighian tubules and larger up to  $16 \times 12\mu$ , toward the rectal valve region. The musculature is a uniform band  $4\mu$  thick of circular muscle which does not conform to the infolding epithelium and therefore, in the relaxed state, creates a space between it and the infolded epithelium. No longitudinal muscles are apparent but an

external mesh of interconnecting muscle fibres presents a distinction from the *rectal valve* with its regular bands of closely packed circular muscles, each muscle band of the valve being about  $6\mu$  wide and  $12\mu$  thick. About twenty such bands run transversely over the valve. No longitudinal muscles are apparent.

Figure 11 shows the rectal valve in the open position. The valvular action is performed by a thin, muscle-controlled epithelial annulus which projects into the lumen like a diaphragm. In longitudinal sections this annulus appears as a pair of flaps from either wall. The valve intima bears a complex but orderly arrangement of spines, the direction of which is determined by the position of the valve, whether open or closed. In Figure 10 the peritrophic membrane is seen being pulled through by the spines of the valve intima.

The annulus appears to be composed of epithelial cells with small nuclei ( $3 \times 2\mu$ ) connected externally to the circular muscles by connective tissue, which can also be seen surrounding the muscle bundles.

The epithelium is cuboidal in the proximal region and becomes more pavement-like near the annulus. Posterior to the annulus the cuboidal form is again assumed. Throughout the valve the epithelium is deep-staining and the cytoplasm granular — almost suggestive of a secretory function. Neither globules nor vacuoles were seen, however.

At least one function of the rectal valve appears to be that of aiding in the passage of the peritrophic membrane through the hind-gut (16). Note Fig. 10.

The *rectum* commences posterior to the rectal valve with the *posterior intestine*, a tubular structure which has about the same diameter as the anterior intestine (about  $130\mu$ ), or which may be distended with food to at least twice this diameter (Figs. 11, 13). Its histology is similar to that of the anterior intestine. The musculature is a thin layer ( $2-3\mu$  thick) of circular bands. Toward the pouch region longitudinal muscles appear externally.

The *rectal pouch* (Fig. 1) is a muscular translucent sac enclosing four papillae. The epithelium of the pouch wall is very thin, and may be much folded during contraction. The cells are low, cuboidal, containing small nuclei ( $8 \times 6\mu$ ). The cuticula appears to be a uniform, spineless sheet about  $1\mu$  thick. The musculature consists of outer circular bands ( $6-12\mu \times 6-10\mu$  thick) very closely packed, overlying inner, longitudinal bands  $4.5\mu$  wide  $\times 7\mu$  thick. These latter are continuous with those of the posterior intestine.

The *rectal papillae* (Figs. 14, 15) are cone-shaped with an inner lumen opening into the body cavity, and their narrowed tips directed into the pouch lumen. The papillae measure  $112-120\mu$  in diameter at the base and are  $170-210\mu$  long. They exhibit both cortical and medullary regions. The medulla consists chiefly of tracheal branches from the haemocoel. These give rise basally to cortical tracheal branches which run longitudinally through the cortex then branch in the intercellular spaces and ramify through the cortical cells as intracellular tracheae (35). The cortical cells are largest near the base ( $60-70\mu$  high), stain lightly but not homogeneously. Their granular cytoplasm is denser toward the lumen and between the cells can be seen the "intercellular spaces" of Graham-Smith (16). Their nuclei are large, ( $10 \times 12\mu$ ) and basal, that is, toward the external cuticula.

Externally the papillae are covered with a loose intima  $1\mu$  thick bearing short spines  $3-6\mu$  long.

The *anal rectum* is the third and last region of the hind-gut. It narrows posteriorly and shows no differentiation other than that already described for the anterior intestine. The musculature thickens toward the anus, probably performing the function of an anal sphincter.

#### MALPIGHIAN TUBULES

No attempt will be made to describe the intricate but apparently constant coursing of the four Malpighian tubules which arise in pairs from a common stalk, one from either side of the posterior end of the post-helicoid region of the ventriculus. The tubules measure not less than



19.35 mm. in length. They are found attached by tracheae to the visceral organs and for this reason are most difficult to unravel. In living specimens the tubules are yellow in colour probably owing to excreted calcium salts (31).

The common ducts are about  $210\mu$  long and approximately  $80\mu$  in diameter. Their bulging epithelial cells are deep-staining and cuboidal ( $10\text{--}14\mu \times 10\text{--}14\mu$ ). The free surface of the epithelium is lined by a distinct brush border about  $2\mu$  high which in the common ducts does not stain as deeply as the epithelium. Inner circular and scattered outer longitudinal muscles are seen.

The tubules (Figs. 8, 11) consist of irregular epithelial cells, 1 or 2 appearing in a cross section, with large round to oval nuclei ( $20\mu$  diameter to  $34 \times 12\mu$ ). In some regions the brush border is indistinct but the basement membrane is distinct throughout. The lumen is not regular but shows the bulging of the irregular cells of variable thickness. Distally the tubule epithelium becomes thinner. On occasion the distal ends of the tubules may be dilated.

### THE SALIVARY GLANDS

The *salivary glands* are a pair of uniform tubules  $46\mu$  in diameter and at least 7.6 mm. long. The salivary glands unite to form a *common salivary duct* ventral to the cervical commissure and slightly anterior to the thoracic ganglionic mass (Fig. 1). From this point the glands pass dorsally and posteriorly flanking either side of the "proventriculus" where they loop extensively then pass posteriorly on either side of the ventriculus to the abdomen. In the abdomen they may pass as fairly straight tubules as far posteriorly as the origin of the malpighian tubules or they may pass no further posteriorly than the first two abdominal segments where they again coil extensively.

In cross section a tubule consists of a single layer of approximately 6 cells which manifest a distinct hyaline border beneath a very thin intima. A distinct basement membrane is present. Each cell has a small round nucleus  $5\text{--}6\mu$  in diameter. The cytoplasm is deep-staining and granular basally and around the nucleus, but distally it stains lightly and may be vacuolar and almost spongy. Vacuolation which is frequently seen around the nucleus may be an artifact and not of secretory significance.

The salivary duct passes anteriorly to the head through the occiput then ventrally to the labial epipharyngeal region. The salivary duct is tubular ( $27\mu$  diameter) lined with thickened ( $2\mu$ ) chitinous rings and in optical section looks superficially like a small trachea. The external surface is studded with flattened, prominent nuclei  $5\mu$  in diameter with practically no cytoplasm and apparently no basement membrane. Towards its distal end (Fig. 1) the duct shows a dilatation, the *salivary syringe* or pump, about 0.1 mm. long. The epithelium beneath the somewhat thickened and rugose intima is cuboidal ( $7 \times 8\mu$  wide) with oval nuclei  $4 \times 6\mu$  diameter. The musculature of the syringe is on the anterior wall consisting of a narrow longitudinal band  $5\mu$  wide which runs dorsally to the basal end of the cibarium near the oesophageal sphincter. At the posterior end of the syringe an epithelial flap is present which probably aids in the control of salivary flow. At its anterior (distal) end the syringe narrows to a duct  $15\mu$  in diameter which opens to the anterior through the hypopharynx.

### THE LABELLAR GLANDS

The *labellar glands* are two rounded glandular masses about  $150\mu$  in diameter situated in the base of the labellum (Fig. 16). In cross section about ten epithelial cells are arranged about a central lumen. Toward the lumen the cells are spongy and vacuolar, and basally the cytoplasm is dense-staining and granular. The nuclei are large ( $12\mu$ ) and a basement membrane is apparent. The lumen connects with a duct  $6\mu$  in diameter which opens to the exterior at the distal end of the labrum.

## SUMMARY

Muscoid flies usually have alimentary tracts with the following characteristics: a helix-like coiling of the ventriculus, a proventricular valve within the cardia (a true proventriculus present in most other insects is absent in muscoid flies), a pedunculate crop and a rectal valve. *H. brassicae* possesses all of these structures; although some muscids such as *Glossina* (31) and *Philacmatomyia* (22) do not have either the helix or the rectal valve.

The musculature varies considerably, correlated with the functions of different regions of the tract. The epithelial cells show variations, which are probably correlated with their cellular activity. Two types of secretion are probably present, vacuolar budding of cytoplasm and granular secretions. The peritrophic membrane is formed in the ventricular portion of the "proventriculus". The complexity of the rectal valve suggests that it is more than merely a device for assisting the passage of the peritrophic membrane.

## ACKNOWLEDGEMENTS

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## LEGEND

a	—	annulus	pf	—	proventricular flange
abv	—	abdominal ventriculus	ph	—	pharynx
ain	—	anterior intestine	phel	—	post-helicoid region
an	—	anus	pin	—	posterior intestine
ar	—	anal rectum	pm	—	peritrophic membrane
b	—	brain	po	—	posterior orifice
brm	—	basal ring muscle	poes	—	proventricular oesophagus
c	—	crop	prl	—	proximal loop
cd	—	crop duct	prov	—	proventriculus
cm	—	circular muscle	pst	—	pseudotrachea
d	—	duct	rp	—	rectal pouch
ea	—	annular pad	rpa	—	rectal papilla
ep	—	epithelia	rval	—	rectal valve
fr	—	food remnants	sd	—	salivary duct
hel	—	helicoid region	sec	—	secretion
in	—	intima	sg	—	salivary gland
is	—	intercellular space	ss	—	salivary syringe
lm	—	longitudinal muscle	t	—	trachea
mt	—	malpighian tubule	tv	—	thoracic ventriculus
ng	—	nerve ganglion	z	—	zone of junction
oes	—	oesophagus			



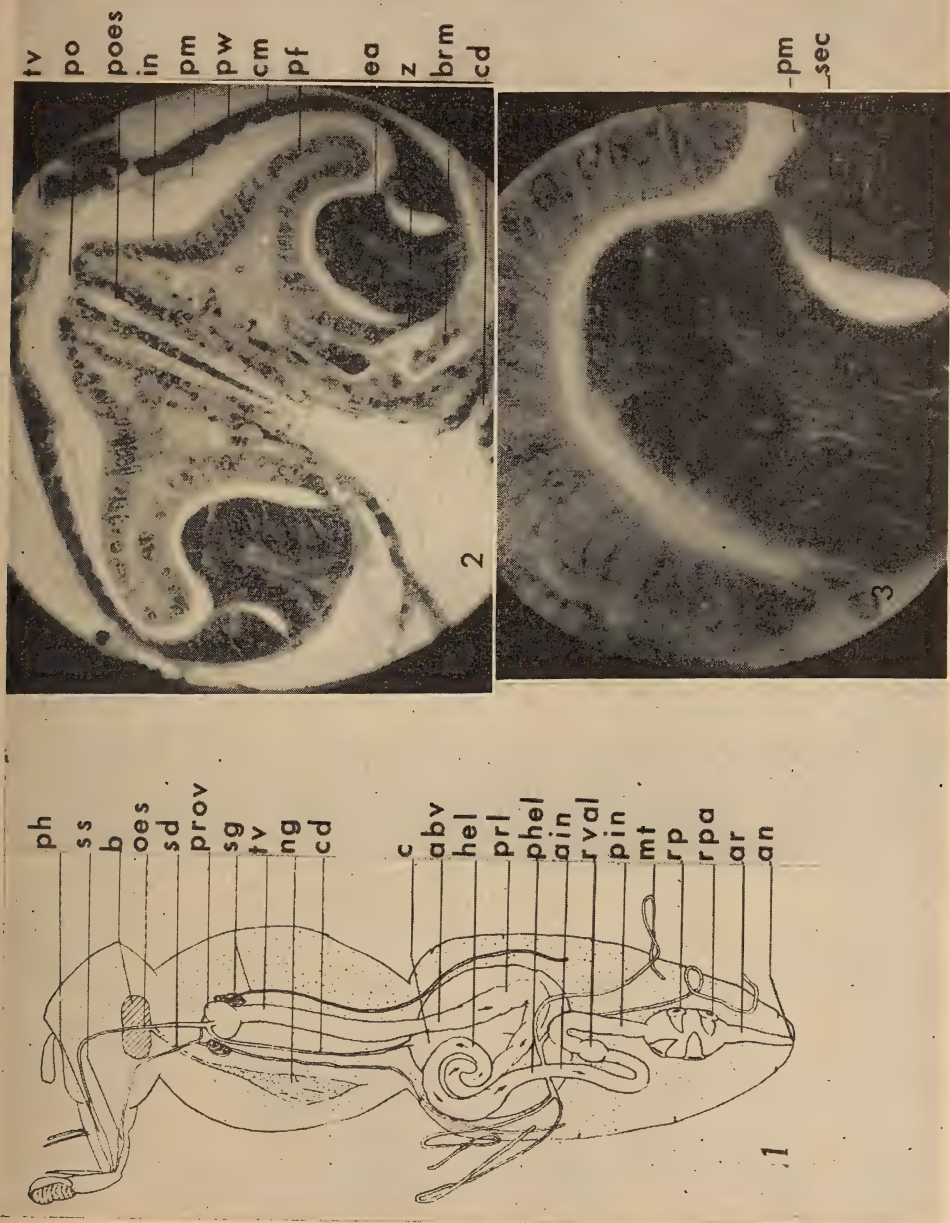


Fig. 1. The alimentary canal, lateral aspect, diagrammatic.

Fig. 2. The "proventriculus", sagittal section x 245.

Fig. 3. The annular pads showing the formation of the peritrophic membrane from the secretion of the dark-staining pad cells of the "proventriculus" x 975.

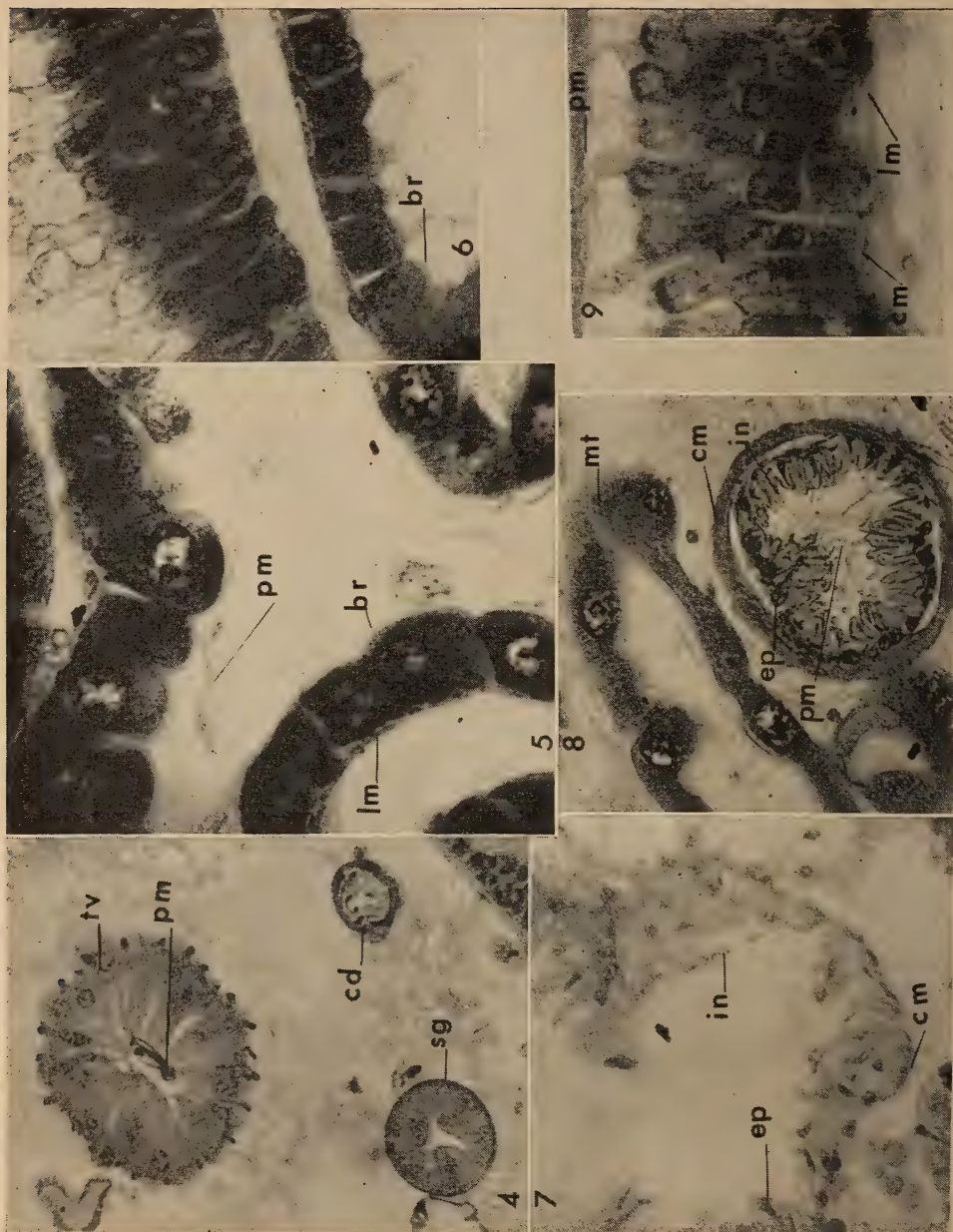


Fig. 4. Showing the thoracic ventriculus (tv) the crop duct (cd) and the salivary gland (sg) in cross section x 90.

Fig. 5. Helicoid region of the ventriculus, typically cuboidal cells with a brush border (br) x 1000.

Fig. 6. Tall columnar cells of the proximal loop of the ventriculus and the cuboidal cells of the post-helicoid region longitudinal section x 1000.

Fig. 7. The crop longitudinal section x 440.

Fig. 8. The anterior intestine near the rectal valve, cross section x 440.

Fig. 9. Thoracic ventriculus, longitudinal section x 1000.



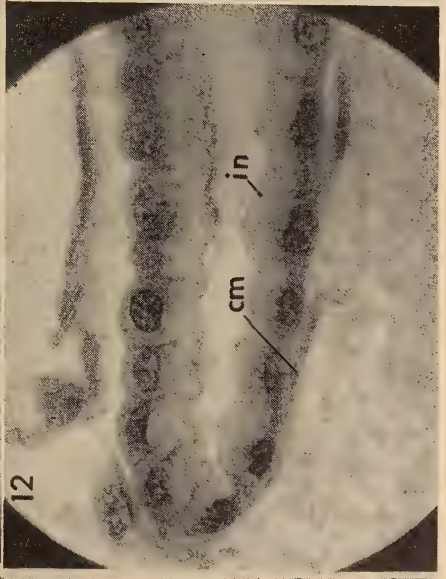
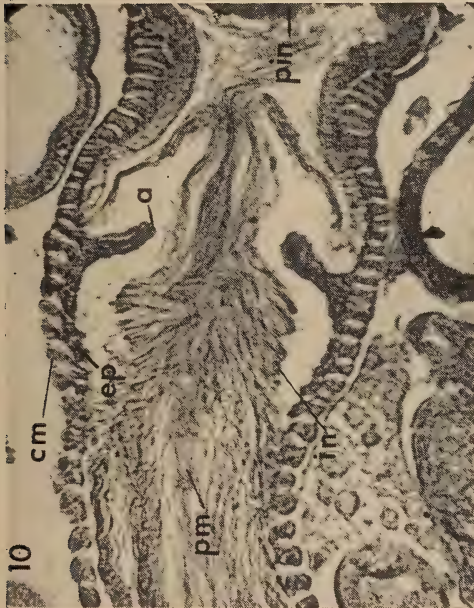
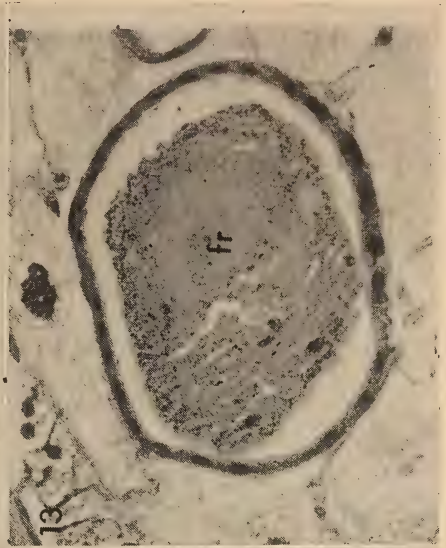
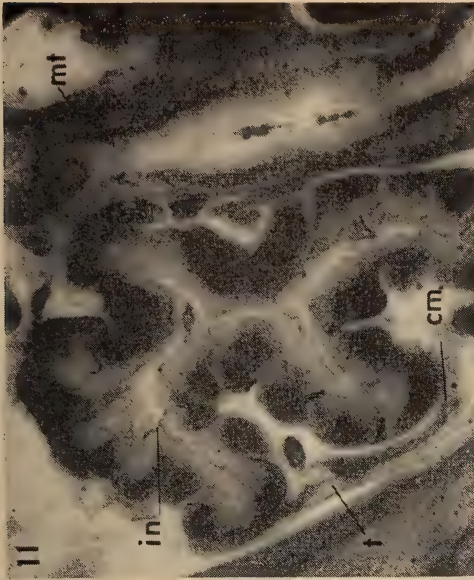


Fig. 10. Rectal valve, open position sagittal section x 440.

Fig. 11. Posterior intestine cross section x 1000.

Fig. 12. Anterior intestine longitudinal x 1000.

Fig. 13. Posterior intestine distended with food, the space is artificially produced. Cross section x 440.



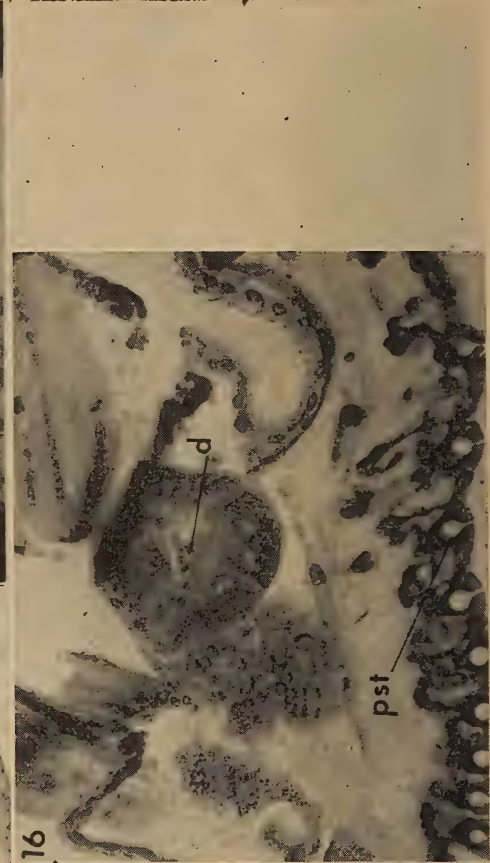
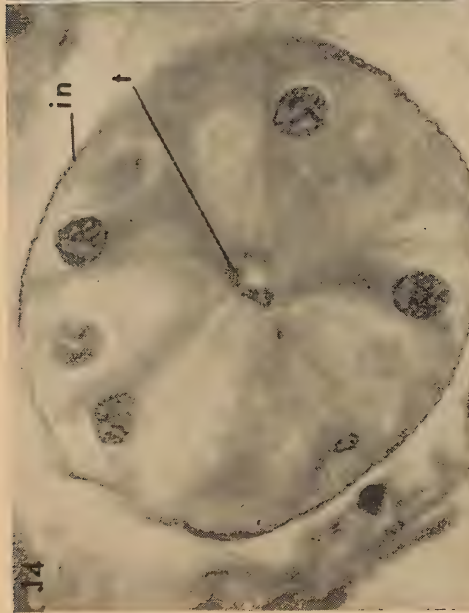
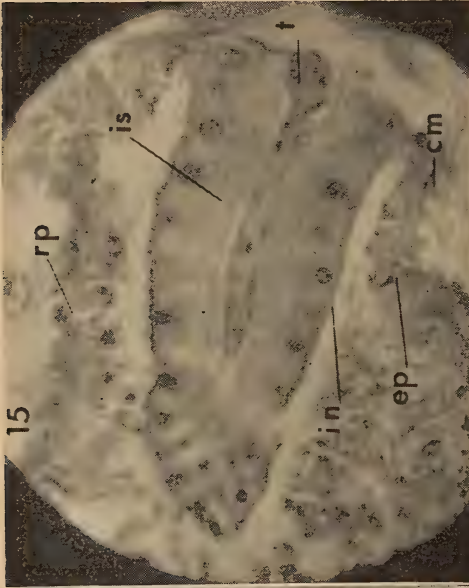


Fig. 14. Rectal papilla cross section x 820.

Fig. 15. Rectal papilla longitudinal section x 500.

Fig. 16. Labellar gland cross section x 440.

## COCOONS OF SOME SAWFLIES THAT DEFOLIATE FOREST TREES IN MANITOBA AND SASKATCHEWAN<sup>1</sup>

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### INTRODUCTION

This research was undertaken to estimate the value of cocoons as a criterion for the determination of the families and genera of sawflies that defoliate forest trees in Manitoba and Saskatchewan. The study was mainly confined to those insects actually reared by the author. Observations of a large number of sawflies reared indicate that the shape and texture of cocoons are generally constant for a given species. However, in both natural and artificial environments, the shape and texture may be modified by the amount of food, humidity, temperature, and by weakening factors such as parasitism.

Several writers have described sawfly cocoons and noted their habitats. MacGillivray (1913) has reported the method by which a number of sawfly larvae prepare for pupation. Rohwer and Middleton (1922) have described cocoons of several species of the tribe Cladiini. Frost (1925) gave an account on the cocoons and habitats of many leaf-mining sawflies. Schaffner and Middleton (1950) published similar information on the most common forest sawflies. In Europe, some of the characteristics of sawfly cocoons of a number of species have been given by Balachowsky and Mesnil (1935-1936) and Enslin (1912-1918). The descriptions of sawfly cocoons are generally meagre, and literature on the identification of sawfly cocoons to family or genus is apparently absent.

### GENERAL CHARACTERISTICS OF SAWFLY COCOONS

The cocoons of sawflies that defoliate forest trees are made of silk, or silk with soil, sand, leaves, twigs, frass, etc., incorporated with them. Their texture is generally leather-like (firm, relatively thick-walled, opaque, and usually polished) or parchment-like (flexible, loosely constructed, thin-walled, polished or dull, and may be translucent). Usually the cocoons have one or two walls, with or without small openings in the outer wall. A normally single-walled cocoon will be double-walled if it contains a larva of an ichneumonid parasite. In such cases, the second wall is of a very thin parchment-like material (e.g. *Mesoleius tenthredinis* Morley, in cocoon of *Pristiphora erichsonii* (Htg.)). The cocoons may be of various shapes; they may be flattened, irregularly oval, ellipsoidal, or tapered at one end. Their surface is smooth or roughened, with the interior generally polished and smoother than the exterior.

Many species of sawflies that attack forest trees pupate in earthen cells or in rotted wood. Species of *Acantholyda*, *Cephalcia*, *Neurotoma*, *Tenthredo*, *Rhogogaster*, *Empria* (*Parataxonus*) and some *Amauronematus*, pupate in earthen cells in the ground. These earthen cells are covered inside with silk or glue which forms a polished surface. On the other hand, species of *Allantus*, *Macremphytus*, *Nematus* (*Pontania*) pupate in rotted wood or make thin parchment-like cocoons in wood.

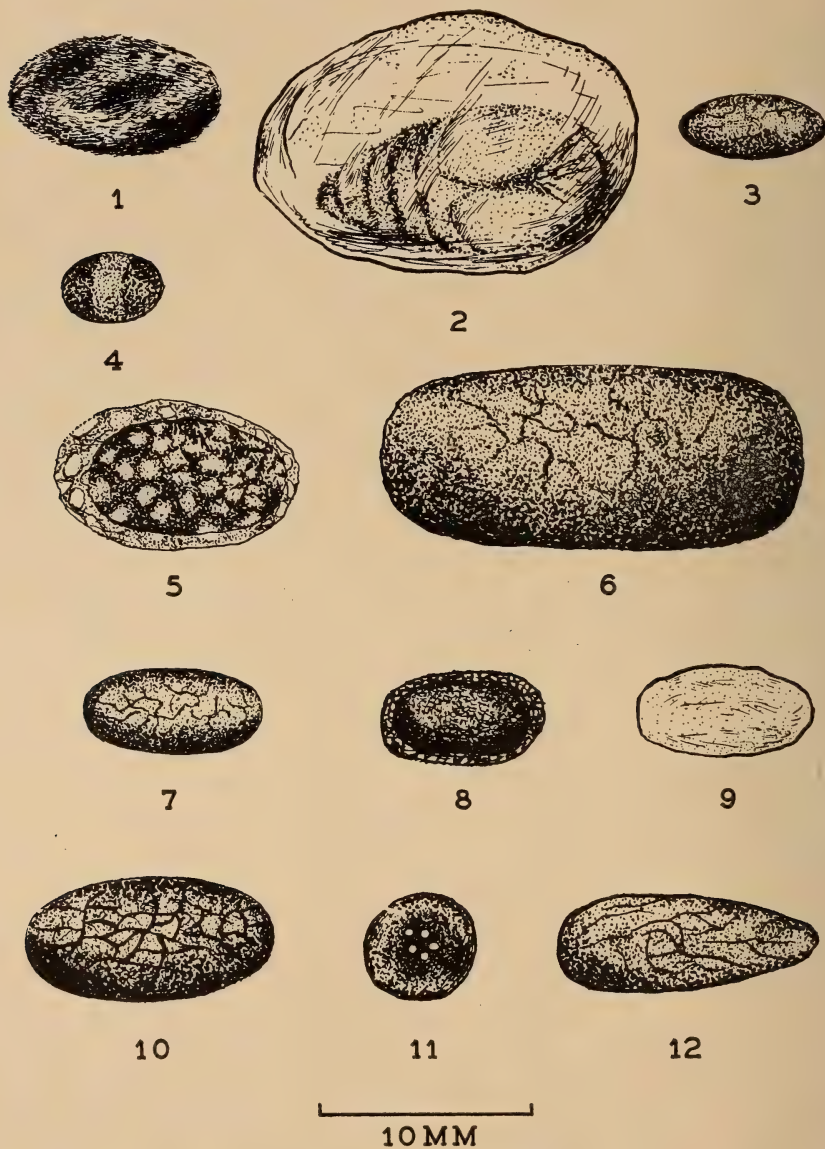
### COCOONS OF OTHER INSECTS

Cocoons formed by some Lepidoptera (e.g., *Tetralopha asperatella* (Clem.), *Meroptera praveella* (Grt.), and *Schizura leptinoides* (Grt.)) and some hymenopterous parasites resemble those of sawflies with which they may be easily confused. Generally, lepidopterous cocoons that resemble those of sawflies are not leather-like, but more of a wool-like consistency. Coarse

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silken strands. or silken strands of irregular texture usually found on the surface of sawfly cocoons, are generally absent in the Lepidoptera which form a cocoon (Fig. 1). If the lepidopterous cocoon is of thin parchment-like material, the obtecded pupal case of the moth can be seen within the structure (Fig. 2).



B. McLeod

Fig. 1-10 and 12; dorsal view of cocoon. 1. *Tetralopha asperatella* (Clem.). 2. *Schizura leptinoides* (Grt.). 3. *Dusaona vicina* (Prov.). 4. *Phobocampe* sp. 5. *Arge pectoralis* (Leach). 6. *Trichiosoma triangulum* Kby. 7. *Neodiprion americanus banksianae* Roh. 8. *Monoctenus melliceps* (Cress.). 9. *Priophorus pallipes* (Lep.). 10. *Pristiphora erichsonii* (Htg.). 12. *Pikonema alaskensis* (Roh.). Fig. 11; end view of cocoon. *Amauronematus* sp.



The cocoons of parasites that resemble sawflies are generally more tapered at both ends (Fig. 3). In some parasitic species, however, the cocoon is not so tapered, but a light-ringed area is present in this centre (Fig. 4). This ringed area is present and visible also in some newly formed sawfly cocoons, but it later disappears as the cocoons take on a darker hue. The surface of parasitic cocoons is generally smooth compared with the roughened surface of many sawfly cocoons. Cocoons of some parasites are also composed of a thin, transparent, parchment-like material, but the enclosed parasitic larvae can be easily distinguished from sawfly larvae.

#### SPECIFIC CHARACTERISTICS OF COCOONS ACCORDING TO FAMILIES

In this paper, the classification of sawflies follows that adopted by Ross (1937), and Ross, Ries, Middlekauf and Stannard (1951). Those sawflies which construct cocoons, and which defoliate forest trees, belong to the families Argidae, Cimbicidae, Diprionidae, and Tenthredinidae. The following is a description of the cocoons of genera and species of these families, reared by the author.

##### ARGIDAE

In this family, *Arge* is the only genus associated with forest trees. The cocoons are roughly oval with double walls (Fig. 5). The outer wall is dull, and is either netted or has small irregularly spaced openings on the sides. The inner wall is dull parchment-like, and may be either separated from or adhering to the outer wall. Colour buff to brown. Length 10-15 mm. Hosts of species reared: birch, hawthorn, willow, poplar, alder, rose, and cherry. Cocoons are spun in leaf litter on the ground. Species reared: *A. pectoralis* (Leach) and *A. clavicornis* (F.).

##### CIMBICIDAE

The cocoons are generally single-walled, shining, leather-like, and cylindrical with rounded ends (Fig. 6). If the cocoon is dissected, a partial second wall may sometimes be present. This second wall is more evident in cocoons of *Zaraea*. Colour reddish-brown to black. Length 13-22 mm. Hosts of species reared: willow, poplar, honeysuckle, cherry, alder, birch, elm, and saskatoon. Cocoons are generally constructed in leaf litter and topsoil. Species reared: *Zaraea inflata* Nort., *Z. americana* Cress., *Trichiosoma triangulum* Kby., and *Cimbex americana americana* Leach.

##### DIPRIONIDAE

*Neodiprion* and *Monoctenus* were the only genera reared in Manitoba and Saskatchewan. Cocoons of *Diprion*, including its subgenus *Gilpinia*, reared in Eastern Canada, were also examined. The cocoons are single-walled, leather-like, shining, and ellipsoidal (Fig. 7). The only exception is found in *Monoctenus*, where the cocoons have double walls and are not shining. The outer wall is loosely constructed of coarse silken strands, with particles of earth adhering to it; the inner wall is leather-like, shining, and cylindrical with rounded ends (Fig. 8). The only significant difference noted between the genera with single-walled cocoons is that cocoons of *Diprion similis* (Htg.) appear to be more robust and have thicker walls. Colour buff to reddish-brown. Length 6-12 mm. Hosts of species reared: pine, spruce, cedar, and juniper. Cocoons are constructed among the needles on the twigs, and in litter and topsoil. Cocoons of *Monoctenus* were formed usually in the soil. Species reared: *Neodiprion abietis* (Harr.), *N. swaini* Midd., *N. nanulus* Schedl, *N. americanus banksianae* Roh., *N. virginiana* Roh., *N. americanus dyari* Roh., and *Monoctenus melliceps* (Cress.).

##### TENTHREDINIDAE

Cocoons of the Tenthredinidae, which is the largest family of sawflies, showed the greatest variation in shape, texture, colour, size, and habitat. Unlike those of the other families, the larvae of Tenthredinidae feed on either deciduous or coniferous trees. Cocoons in the genera *Nematus* and *Amauronematus* may be single- or double-walled as explained in the following pages.

The species of the tribes Nematini and Cladiini of the subfamily Nematinae cause the greatest damage to forest trees. Cocoons of the tribe Cladiini are easily recognized by their irregular oval shape and paper-thin walls, which are transparent or semi-transparent. Walls may be single or double according to the genera and species. These cocoons are about 8-14 mm. long, light-brown to brown in colour and are usually attached to a leaf such as birch, willow, cherry, aspen, or to objects such as the rearing jar (Fig. 9). Species reared: *Priophorus pallipes* (Lep.).

It is in the tribe Nematini that the cocoons show the greatest variation. The following descriptions are of cocoons of the more common genera.

#### *NEMATUS* (PTERONIDEA) Rohwer

Cocoons may be dull or shining, flattened, irregularly oval, cylindrical with rounded ends, or tapered at one end. Cocoons may be made of a leather-like or parchment-like material with single or double walls. If single-walled cocoons are dissected, a partial second wall may be present as in Cimbicidae. The walls of some cocoons have earth incorporated or adhering to them. Flattened and irregularly oval cocoons are usually parchment-like, semi-transparent, or opaque, often with heavy silken strands on the sides. Cylindrical cocoons like *N. hyalinus* (Marl.) are usually leather-like and opaque; those with double walls like *N. possibly chalceus* (Marl.) may have small openings in the outer wall at one or both ends. Cocoons with one end tapered may be made of either parchment-like or leather-like material. Colour: yellow, light-brown, brown, dark-brown, or reddish-brown. Length 7-14 mm. Hosts of species reared: willow, poplar, birch, maple, alder, and gooseberry. Cocoons are formed between leaves, next to the glass of the rearing jar, in litter, between litter and soil, and in soil. Species reared: *N. pinguidorsum* Dyar, *N. mendicus* Walsh, *N. limbatus* Cress., *N. hyalinus* (Marl.), *N. ribesii* (Scop.), *N. possibly chalceus* (Marl.), and several species of unidentified *N. (Pteronidea)*.

#### *NEMATUS* (PONTANIA) O. Costa

Cocoons of species reared have single walls. They are shining, leather-like or parchment-like, cylindrical, with rounded ends. The leather-like cocoons resemble those of *Pristiphora* (as explained below), but are smaller. Colour brown or dark-brown. Length 5-6 mm. Hosts of species reared: poplar and willow. Cocoons are constructed between leaves, on leaves, within a folded leaf, between litter and topsoil, and in soil. Cocoons formed in rotted wood or in galls are generally thin and parchment-like. Species reared: *N. bozemani* (Cooley), and *N. (Pontania)* spp.

#### *ANOPLONYX* Marlatt

Cocoons are dull, cylindrical, with double walls. Soil, leaves, and litter are bound to their outer wall. The outer wall is not readily discernible in some cocoons reared under artificial conditions; loose silken strands, however, are generally on the surface, especially at both ends of the cocoon. The inner wall is shining, parchment-like. Colour light-brown to brown. Length 6-8 mm. Host of species reared: larch. Cocoons are formed in litter or between litter and topsoil. Species reared: *A. luteipes* (Cress.) and *A. occidentis* Ross.

#### *PRISTIPHORA* Latreille

Cocoons are leather-like, shining, single-walled, cylindrical, with rounded ends. Coarse silken strands are usually found on the surface of cocoons (Fig. 10). Colour generally dark-brown. Length 6-12 mm. Host of species reared: larch, birch, spruce, and willow. Cocoons are formed between leaves, in litter and soil, and in soil. Cocoons of *P. erichsonii* (Htg.) are sometimes formed in old emerged cocoons. Species reared: *P. erichsonii* (Htg.), *P. sycophanta* Walsh, and *Pristiphora* spp.

#### *AMAURONEMATUS* Konow

Cocoons may be dull or shining, flattened, irregularly oval, cylindrical, with rounded ends, or with one end tapered. They are generally single-walled with the texture either parchment-like or leather-like. Soil adheres to or is incorporated with the walls of some cocoons. If the

cocoon has a double wall, it is usually parchment-like. One of the distinguishing characteristics of single-walled cocoons is the presence of 3 to 25 pores at one or both ends of the cocoons (Fig. 11). A partial second wall may also be present in some cocoons of this genus. Colour: light-brown, brown, or reddish-brown. Length 6-13 mm. Hosts of species reared: willow, poplar, larch, alder, and oak. Cocoons are constructed between leaves, in litter, between litter and topsoil, and in soil. Some species of this genus do not construct cocoons, but form earthen cells in which to pupate. Because of the need for revision of the genus, no attempt was made to identify the various species of *Amauronematus* reared.

#### PIKONEMA Ross

Cocoons are single-walled, more or less shining, elongate, with one end rounded and the other end tapered to a blunt point. Several layers of silken strands are present at the pointed end of the cocoon. Coarse silken strands are usually evident on the surface of the cocoon (Fig. 12). Some cocoons may have soil, frass, or leaves adhering to them. Colour dark-brown to black. Length 9-11 mm. Host of species reared: spruce. Cocoons are formed in litter and topsoil, in soil, and between the needles on the twigs. Species reared: *P. alaskensis* (Roh.), and *P. dimmockii* (Cress.).

#### NEMATINUS Rohwer

Cocoons are cylindrical with double walls. The outer wall is dull, loosely constructed of coarse silken strands with earth and sand incorporated and adhering to it. The inner wall is shining and leather-like. Colour brown. Length 8-9 mm. Host of species reared: birch. Larvae form cocoons in the soil. Species reared: *N. unicolor* (Marl.).

#### CROESUS Leach

Cocoons are single-walled, shining, irregularly oval, rounded at one end and tapered at the other. Loose, silken strands are evident at the pointed end. Colour very dark reddish-brown or black. Length 9-11 mm. Host of species reared: birch. Cocoons constructed between litter and soil, and in soil. Species reared: *C. latitarsus* Nort.

#### PLATYCAMPUS Schiödt

Cocoons are cylindrical, with double walls. The outer wall is dull, made of coarse silken strands with soil incorporated and adhering to it; the inner wall is shining, more leather-like than parchment-like. Colour brown. Length 7 mm. Host of species reared: poplar. Cocoons formed in the soil. Species reared: *P. americanus* (Marl.).

#### HEMICHROA Stephens

Cocoons are dull, irregularly oval, and double-walled. The outer wall is composed of silken strands with earth and sand incorporated and adhering to it; the inner wall is thin and parchment-like. Colour brown. Length 10-12 mm. Host of species reared: alder. Cocoons constructed in the earth, between litter and soil. Species reared: *H. crocea* (Fourc.).

#### KEY TO SEPARATE THE PRECEDING FAMILIES

- |   |                          |
|---|--------------------------|
| 1. Cocoons with single wall (Figs. 6, 7, 10) .....                  | 2                        |
| Cocoons with double wall (Figs. 5, 8) .....                         | 7                        |
| 2. Cocoons made of parchment-like material (Fig. 9) .....           | Tenthredinidae (In Part) |
| Cocoons made of leather-like material .....                         | 3                        |
| 3. Cylindrical with rounded ends .....                              | 4                        |
| Not cylindrical, flattened, or with one end tapered (Fig. 12) ..... | Tenthredinidae (In Part) |
| 4. 3-25 small opening at one or both ends (Fig. 11) .....           | Tenthredinidae (In Part) |
| No small openings at one or both ends .....                         | 5                        |



- |   |   |
|---|---|
| 5. Length 13 mm. or over (Fig. 6) .....   | 5                                       |
| Length under 13 mm. ....  | 6                                       |
| 6 No heavy silken strands on surface; without earth incorporated into make-up of cocoon; over 6 mm. in length (Fig. 7) .....  | Diprionidae (except <i>Monoctenus</i> ) |
| Heavy, dark silken strands on surface (Fig. 10); or with earth incorporated or adhering to cocoon; or less than 6 mm. in length .....                               | Tenthredinidae (In Part)                |
| 7. Outer wall of cocoon netted or with small openings on sides (Fig. 5) .....   | Argidae ( <i>Arge</i> )                 |
| Silken strands of outer wall of cocoon criss-cross (Fig. 8), or without small openings on sides, with or without earth incorporated or adhering to outer wall ..... | 8                                       |
| 8. Outer wall of cocoon without small openings on side; if silken strands of outer wall criss-cross, not associated with cedar or juniper .....                     | Tenthredinidae (In Part)                |
| Silken strands of outer wall of cocoon criss-cross, associated with cedar or juniper (Fig. 8) .....   | Diprionidae ( <i>Monoctenus</i> )       |

### DISCUSSION

In this paper an attempt has been made to characterize the main families of sawflies that defoliate forest trees in Manitoba and Saskatchewan, by the study of the species which spin a cocoon.

Though only a limited number of species were examined and many of these were reared under artificial conditions, the results show that cocoons within the families Argidae, Cimbicidae, and Diprionidae (excepting the genus *Monoctenus*), are constant as to shape and texture. On the other hand, cocoons of the family Tenthredinidae are variable. However, in the subfamily Nematinae, cocoons of the tribe Cladiini appear to be constant. They are variable in the tribe Nematini, except in the genera *Pristiphora*, *Anoplonyx Pikonema*, and *Nematus* (*Pontania*), where they appear to be constant when the cocoons are formed in litter and soil. Though several cocoons of only one species were examined in the genera *Croesus*, *Hemichroa*, *Piatycampus*, and *Nematus*, their shape and texture also appears to be stable. The greatest variations were found in the genera *Nematus*, and *Amauronematus*.

It is interesting to note that in the case of *Pristiphora*, the texture and shape of the cocoon constructed by larvae feeding on deciduous or coniferous trees were the same. The shape of the cocoon will be influenced by its position in its habitat. When larvae use the surface of leaves, twigs, or rearing jars for spinning their cocoons, heavy silken strands do not occur on that side of the cocooning surface. The basal shape of the cocoons will generally conform to the shape of the surface on which the cocoon is spun.

Environmental conditions may also influence the texture and colour of the cocoon. For example, cocoons formed in a dry medium are more lightly coloured than those formed under moist conditions.

Cocoons of sawflies of different families are often similar in shape and texture. However, distinguishing characteristics in habitat, host, colour, and size, permit their classification into their respective families.

### ACKNOWLEDGMENT

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## NOTES ON THE FEEDING OF LARVAE OF THE LARCH SAWFLY, *PRISTIPHORA ERICHSONII* (HTG.) (HYMENOPTERA: TENTHREDINIDAE)<sup>1</sup>

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### INTRODUCTION

The larch sawfly, *Pristiphora erichsonii* (Htg.), is an oligophagous insect which feeds upon foliage of *Larix*. Currently this insect is present in populations of outbreak proportions in forested areas of Ontario, Manitoba, and Saskatchewan, and neighbouring regions of the United States. In this part of its range, the native host species is *Larix laricina* (Du Roi) K. Koch.

General accounts of the biology of the larch sawfly can be found in the writings of Hewitt (3), Lejeune (5), Packard (8), and Watson (9). This paper is an account of the larval feeding habits and related factors affecting the defoliation pattern, and a consideration of the quantitative aspects of feeding as revealed by frass studies.

### FEEDING CHARACTERISTICS AND DEFOLIATION PATTERN

The feeding characteristics of larch sawfly larvae and the resulting defoliation pattern are conditioned primarily by the following factors: the oviposition habits of the adults; the distribution of new terminals in the tree crown; and the light reactions and related behaviour of the feeding larvae.

The ovipositing adult inserts its eggs in the tissues of the newly developing terminal shoots at the bases of the soft, partly formed needles. A study of the distribution of the terminal tips in the crown (6) has revealed that the largest number of these are found in the central third of the crown. A somewhat smaller number of shoots occur in the upper third while the fewest are located in the lower third of the crown.

The numbers of utilized oviposition sites, as revealed by the persistent curled tips, were found to have the same distribution. The percentage of available terminals that were selected as oviposition sites showed a different distribution however. This percentage was found to in-

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crease from the bottom to the top. Hence, at the time of hatching the larvae tend to be distributed peripherally in the crown with the greatest concentration being found in the comparatively thinly foliated distal third of the crown.

The newly hatched larvae do not feed on the needles of the terminal shoot in most cases, but move to the whorls of needles on the woody twig proximal to the terminal. The initial feeding is confined to the edges of the needles but after the first stadium they consume whole needles, working from the tip to the base. The larvae are gregarious feeders, several individuals from a given egg cluster usually feeding together on a single verticil. During the first four stadia, movement from the site of oviposition is restricted. Such movement as does occur is directly associated with feeding activity and this constitutes a migration along the branch to ward the main axis with the destruction of each verticil of needles contacted. The fifth instar larva is more active and its greater foliage consumption necessitates increased foraging.

The movements of larvae on the tree are conditioned to a considerable extent by their photic responses. This is especially true of the more active fifth stage larvae. Under the conditions of a two-light experiment, fifth stage larvae were found to exhibit a strong photo-positive behaviour. This was true of larvae preconditioned in either the dark or light and of both fully fed and partially starved individuals. The reactions of larvae of the earlier stadia could not be reliably determined due to their restricted movement particularly when on a plane surface. When fifth stage larvae were placed individually on the proximal portion of a branch, in almost all cases, they moved distally to the extremity of the woody twig. If this was stripped of needles, they retraced their paths and proceeded out on one of the laterals, invariably toward the light source. Feeding did not commence until the larvae reached the peripheral whorl of the lateral.

As a consequence of the ovipositional habits of the adult and of the photo-positive behaviour of the larvae, the extremities of the individual branches and of the crown are always defoliated first. Defoliation in a larch stand is first evidenced by the appearance of the stripped upper crowns. The extent of feeding within a given stand often appears exaggerated due to the conspicuous bare tops. Actually only a relatively small portion of the foliage may have been destroyed.

#### FRASS STUDIES

Larch sawfly feeding was studied quantitatively by measuring the frass yield throughout development. Groups of larvae, each from an individual egg cluster, were reared separately. They were reared under insectary conditions and were provided with a continual supply of fresh foliage. The frass produced was collected at intervals of two days or less, oven-dried, and weighed.

In Table I are presented the data on the relative frass yields of each instar. It was necessary to bulk the frass of the first two instars due to the limited sensitivity of the balance used. The data in this table are based on rearings of fourteen groups of larvae. Initially these groups comprised about thirty larvae. During the last two larval stadia this number was reduced to approximately ten larvae per group.

Table I  
RELATIVE FRASS YIELD OF EACH LARVAL INSTAR

Instar	Duration of Stadium in Days		o/o of Total Frass Yield - Dry Wt. (Mg.)	
	Mean	Range	Mean	S.D. of Groups
I & II	5	2-8	1.3	0.5
III	3	2-6	2.4	1.4
IV	3	2-7	15.3	10.8
V	9	4-14	81.0	10.8



It is apparent from these data that by far the greatest amount of feeding occurs during the final larval stadium. This is due in part to the longer duration of the stadium but it is also a result of the accelerated rate of foliage consumption. This is illustrated by the information in Table II where figures for the absolute frass yields are presented.

Table II  
ABSOLUTE FRASS YIELD OF EACH LARVAL INSTAR

Instar	<i>P. erichsonii</i> (Htg.)				<i>D. hercyniae</i> (Htg.) (Data of Morris, 1949)	
	Total Dry Wt./larva (mg.)	S.D. of Groups	Dry Wt./ larva/day (mg.)	S. D. of Groups	Total Dry Wt./larva (mg.)	Dry Wt./ larva/day (mg.)
I & II	3.6	1.8	0.8	0.9	9	2.5
III	6.3	2.8	2.2	0.8	18	6.0
IV	38.5	23.4	8.9	2.8	56	12.4
V	222.9	65.9	26.6	6.1	292	32.4
Total	271.3	—	—	—	375	—

As a consequence of this disproportionate distribution of activity, defoliation does not become apparent, even in a heavy infestation, until the larvae are near maturity. Reports on other defoliating insects, (*Diprion hercyniae* (Htg.) (7), *Malacosoma disstria* Hbn. (4)), indicate that a similar large proportion of the feeding occurs during the final stadium. The data of Morris for the European spruce sawfly, *D. hercyniae* (Htg.), are included in Table II for purposes of comparison.

A limited study was conducted to determine the relation of frass production to foliage consumption. A few fifth stage larvae were allowed to feed on a known number of measured needles (mean length = 17.3 mm.). The frass pellets produced were counted, oven-dried, and weighed. From this information it was calculated that each milligram of dried frass represented the consumption of 1.6 needles (average length 17.3 mm. and mean dry wt. 0.84 mg.).

Under the conditions in which they were reared these fifth stage larvae utilized ca. 25 per cent of the dry matter of the foliage consumed. Fifth stage larvae are somewhat wasteful feeders due to their incomplete mastication and digestion of the ingested needles. Therefore, the actual over-all utilization of all stages is probably somewhat higher than this. Food utilization (dry wt. basis) of other phytophagous insects, as reported in the literature, is in most cases in the neighbourhood of 35 per cent for the total development period of the larval stages (1, 2).

From these data it was further calculated that the total mean frass drop of 271 milligrams (dry wt.) per larva represented the consumption of 363 milligrams (dry wt.) of needles. This is not to be accepted as an absolute value but rather as a representative figure indicating the order of magnitude. It would be subject to considerable deviation under differing circumstances due to such varying biotic and physical factors as differences in the foliage and temperature fluctuations. This limitation must necessarily be borne in mind in the use of such data as a basis for population measurement, the logical application of such information.

#### SUMMARY

The feeding habits of larvae of the larch sawfly, *Pristiphora erichsonii* (Htg.), are described. The resulting defoliation pattern of the host is related to the ovipositional habits of the adult insect, the photic responses and relative behaviour of the larvae, and the growth characteristics of the host tree.

Quantitative data on frass yield for all larval stages are given. Approximately 80 per cent of the frass-drop occurs during the fifth (final) larval stadium. Data concerning the quantitative relationship between frass yield and foliage consumption are presented and discussed.

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## NATURAL CONTROL OF TABANIDAE (DIPTERA) IN THE REGION OF CHURCHILL, MANITOBA<sup>1</sup>

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#### INTRODUCTION

During the short, sub-arctic summers at Churchill, Manitoba, biting flies of the family Tabanidae often occur in such numbers as to cause considerable annoyance to man as well as animals, particularly in the bush. In common with mosquitoes and black flies, the importance of these pests has been recognized and already much effort has been directed toward studies of their biology and control.

In 1947 Twinn *et al.* (3) investigated biting flies at Churchill and later published a preliminary account of the Tabanidae in this area. During the next two years these studies were continued by Miller (2), who recorded two natural control agents, namely, *Diglochis occidentalis* (Ashm.), a chalcidoid parasite of *Tabanus* spp., and *Prionocera dimidiata* (Lw.), a tipulid

<sup>1</sup>Contribution No. 2962, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada. The results herein reported were obtained by the Division of Entomology in a program of studies on the biology and control of biting flies being carried out on behalf of the Defence Research Board and with the co-operation of that organization and other agencies. This paper was presented at the 88th Annual Meeting of the Entomological Society of Ontario, November 13, 1951.

<sup>2</sup>Agricultural Research Officer.

predator of the larvae of *Chrysops* spp. Miller also suggested spiders and lemmings as natural enemies of tabanid adults. In 1949 James (1) reported *D. occidentalis* from pupae of *Chrysops* spp. and a nematode *Mermis* sp., from an unidentified species of *Tabanus*.

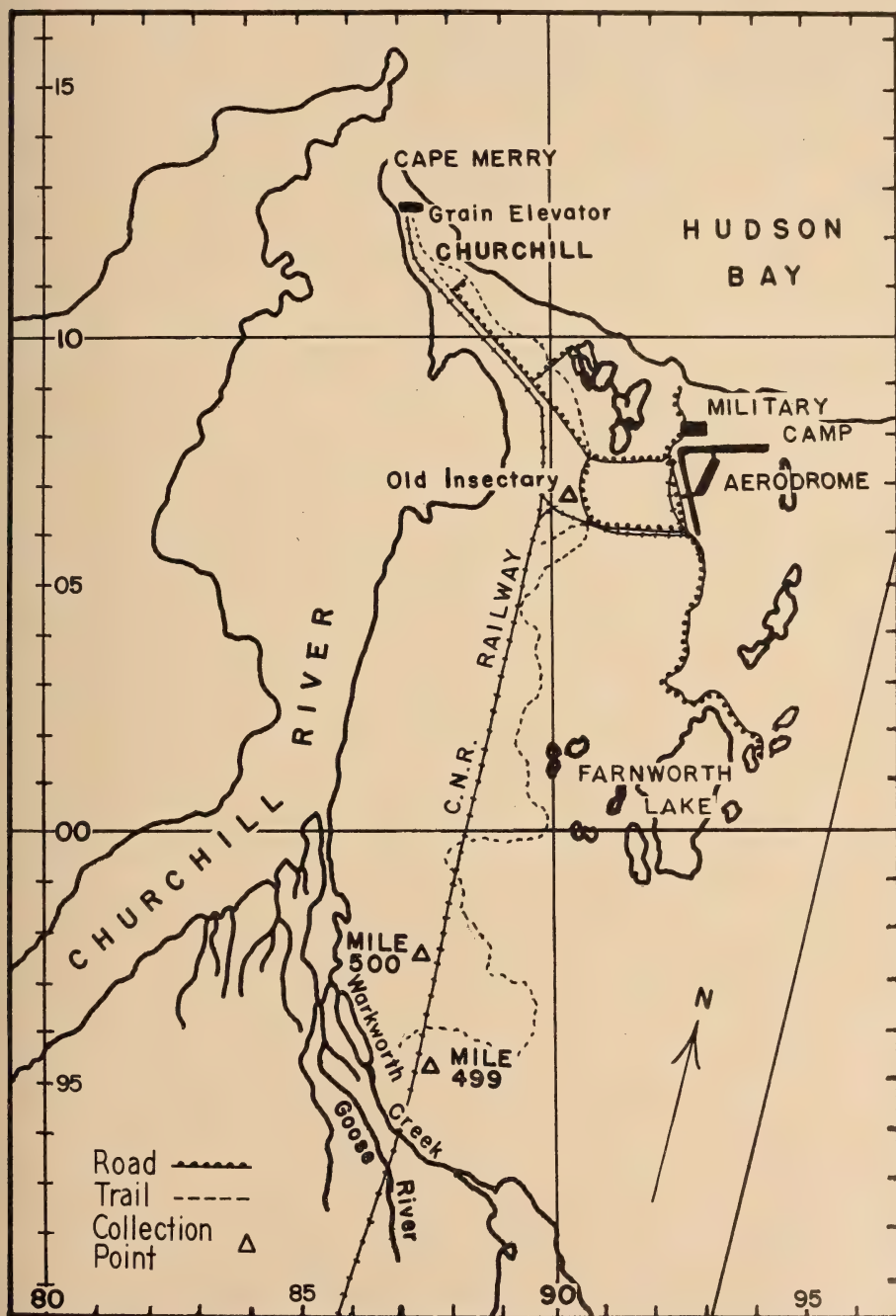


Fig. 1. Map of Churchill area showing collection points.



The studies on natural control were continued by the writer in 1950 in co-operation with Household and Medical Entomology, Division of Entomology. The purpose of these studies was to assess the importance of the parasites previously recorded and to continue the survey for other biotic agents. Accordingly, immature stages of tabanids were collected at several points throughout the summer and data on natural control were obtained through dissections and by rearing in individual jars and vials. The collections were arranged to coincide as far as possible with the seasonal development of the hosts and particularly with those that would mature in 1950.

Collections were made at three sites (Fig. 1). The first was at the Old Insectary, southwest of the military camp; the other two were near Warkworth Creek some ten miles south of Churchill, one east of railway marker Mile 499, the other on the west side of the railroad 200 yards north of Mile 500.

Eggs of *Tabanus* spp. were found for the first time at Churchill by Mr. J. A. Shemanchuk, Household and Medical Entomology, Division of Entomology, near the Old Insectary on August 4. The majority of the egg masses were attached to the undersides of leaves of dwarf birch, *Betula glandulosa* Michx. Series of coloured wooden stakes were placed in suitable tabanid habitats to attract ovipositing females but this method was not effective, one mass only being deposited and this upon a yellow stake. On August 8, 14 egg masses were collected from dwarf birch. The eggs were placed in cotton-stoppered vials with damp moss and incubated in the laboratory. During the ensuing six days, eggs hatched in all but two of the masses but no parasites emerged from any of the eggs either before or after hatching. Later, the unhatched eggs and numbers of first-stage larvae were examined, but there was no evidence of parasitization.

The first collection of tabanid larvae was made at the Old Insectary and at Mile 499 from June 1 to June 16, as soon as the top layers of moss in the tundra-meadow pools had thawed out sufficiently. This material, 137 larvae of *Tabanus* spp. and 84 larvae of *Chrysops* spp., was dissected within a few days of its collection and no insect parasites were found. However, one larva of *Tabanus* sp. contained 20 small nematodes in the body cavity.

The second collection was made at Mile 499 from June 16 to July 2 and consisted of 32 larvae and four pupae of *Tabanus* spp. and 69 larvae and three pupae of *Chrysops* spp. The larvae were taken from a poorly drained bog characterized by an abundant growth of emergent plants such as sedges *Carex capitatus* L., *C. aquatilis* Wahl., and cotton grass, *Eriophorum angustifolium* Honck. Throughout this bog were numerous hummocks supporting dwarf birch, *Betula glandulosa*, and dwarf willows, *Salix* spp. The four pupae of *Tabanus* spp. were found in decaying humus around the edges of a hummock, the pupae of *Chrysops* spp. in coarse, wet moss within one inch of the surface. Larvae were reared individually in 4-oz. or 8-oz. jars containing a small amount of damp moss, and food was added as required. Larvae of *Tabanus* spp. fed mainly on snails and the larvae of tipulids; larvae of *Chrysops* spp., however, obtained nourishment from the moss and organic matter in which they were reared. All pupae were placed in 3-inch shell vials containing damp moss, each vial being lightly plugged with cotton. The jars and vials were examined daily and the pupation and emergence of hosts and parasites recorded.

By July 18, more than half of the larvae (15 of *Tabanus* spp. and 38 of *Chrysops* spp.) had pupated. Up to this time there had been no external signs of parasitization. Later, however, when the parasite *Diglochis occidentalis* began to emerge from the pupae, it was evident that some of the larvae had already been parasitized when collected since they could not have been attacked in the rearing jars. As a rule, pteromalids parasitize the later stages of Diptera. It is not known in what stage tabanids are attacked by *D. occidentalis*, but there is some evidence to suggest attack in the mature larval and the prepupal instars rather than earlier ones. Mature larvae and pupae of *Tabanus* spp. not being available, female adults of *D. occidentalis* were placed in vials with newly hatched larvae of *Tabanus* spp. and puparia of *Pseudosarcophaga affinis* (Fall.). The females appeared to oviposit in the puparia but did not respond to the newly hatched larvae.

The total parasitism in this collection was 13.9 per cent of *Tabanus* spp. and 20.8 per cent of *Chrysops* spp. The host pupae from which the parasite *D. occidentalis* emerged were identified from the pupal skins and Table I shows the various species of Tabanidae that were represented. In general the parasites emerged about one month after the host larvae had pupated.

TABLE I

TABANIDAE PARASITIZED BY *D. OCCIDENTALIS* IN THE SECOND COLLECTION  
AT MILE 499, NEAR CHURCHILL, MAN., 1950.

Species	No. of larvae and pupae	Dates of pupation	Dates of parasite emergence
<i>Tabanus affinis</i> Kby.	1	July 2	August 7
<i>T. frontalis-septentrionalis</i> complex	3	June 28—July 12	August 10—12
<i>Tabanus</i> sp.	1	July 12	—
<i>Chrysops frigida</i> O.S.	2	July 2—8	August 5—7
<i>C. furcata</i> Wlk.	3	June 28—July 6	August 4—6
<i>Chrysops</i> spp.	10	June 28—July 10	August 4

A third collection, including both larvae and pupae, was obtained later in the summer. At Mile 500, 23 larvae and 18 pupae were collected from July 1 to July 8, and at the Old Insectary 8 larvae and 15 pupae were obtained from July 12 to July 21. The larval habitat in the muskeg at Mile 500 was similar to that at Mile 499 but was smaller in extent and less open. Situated in part along a drainage ditch, it was bordered on the west by a dense stand of spruce and tamarack. During the latter part of the summer, grasses and sedges matured in the ditch and most of the water disappeared.

In this collection also, there was no external evidence of larval parasites. Later, *D. occidentalis* emerged from the Mile 500 material, from pupae of *Chrysops* spp. from August 3 to August 14 and from a pupa of *Tabanus frontalis* — *septentrionalis* complex on August 5; also from the Old Insectary material, from pupae of *Tabanus* spp. from August 20 to September 2. The aggregate parasitism (12.5 per cent) was less than that of the second collection (18.5 per cent). Pupal skins of the parasitized hosts were identified as follows:— Mile 500: *Tabanus frontalis-septentrionalis* complex (♂), *Chrysops frigida* O.S. (2 ♀ ♀), *C. furcata* Wlk. (2 ♂ ♂), *C. nigripes* Zett. (♂); Old Insectary: *T. affinis* Kby. (♀) and *T. frontalis-septentrionalis* complex (♂).

Results obtained in rearing the larvae and pupae show that *D. occidentalis* is an important factor in the natural control of tabanids at Churchill. In 1950 adults of this species emerged on August 3 from the third collection and continued emerging until September 2. Thus, adults were present in the field for at least 30 days. It is also evident from the records that the parasite emerged sooner from the *Chrysops* than from the *Tabanus* pupae; for the former a mean of 32 days from the date of host pupation was required; for the latter, 35 days.

The number of individuals from a host pupa was related to the size of the host. On account of their large size more parasites were obtained from the pupae of *Tabanus* spp., one pupa yielding 110 adults. The average from seven pupae of *Tabanus* spp. was 45.5; from 15 of *Chrysops* spp. the average was 16.1.

## SUMMARY

The natural control of tabanids in their immature stages was further investigated during 1950 in the region of Churchill, Manitoba.

Although insect parasites were not found by dissection of overwintered host larvae, extensive parasitization by the chalcidoid *Diglochis occidentalis* (Ashm.) was recorded from reared collections of larvae and pupae. There is some evidence that this parasite attacks the mature host larvae.

No parasites were obtained from the incubation of a small collection of eggs of *Tabanus* spp.

#### ACKNOWLEDGMENTS

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## EFFECT OF PARENTAL FEEDING ON RATE OF DEVELOPMENT OF OFFSPRING OF THE CONFUSED FLOUR BEETLE, *TRIBOLIUM CONFUSUM* DUV. (COLEOPTERA: TENEBRIONIDAE)<sup>1</sup>

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#### INTRODUCTION

Reynolds (1945) concluded that, within the range of flours containing 60 to 80 per cent of whole grain after milling and extracting, the rate of development of the offspring of *Tribolium destructor* Uytten. is dependent on the food of the parents. If this were true of other species in this genus, it would have great practical implications. One would then expect to find the populations in a flour mill more or less evenly distributed in suitable breeding spots. An initial population could build up in the tailings stock, where the food is ideal for insect growth, and development under these conditions would proceed at a maximum rate. Through the mechanics of flour milling the newly emerged adults would be transported to various spots in other milling units where lodged stock would afford suitable breeding places. Then in milling streams of low nutritive value the next generation would develop as rapidly as their parents, and the populations in all milling units would therefore approach the same proportions.

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The examination of flour mills discloses that this is not the case. In general, the population in any milling unit is associated with the nutritive value of the stock lodged in it. Cotton *et al* (1944) observed that the insect population in smiling units containing food of high nutritive value was from  $1\frac{1}{2}$  to 3 times as great as the population in other units containing less nutritious food. Reynolds' results do not hold for *Tribolium confusum* Duv. under practical conditions in flour mills and this study was undertaken to determine if this was also the case under experimental conditions in the laboratory.

## METHODS

The experiments were conducted in temperature cabinets maintained at 32° C. and 75 per cent relative humidity. The variation in temperature was less than  $\pm .2^\circ$  C. All food was taken from single samples of second patent flour and wheat germ. Each individual was allowed one gram of food.

The tests were carried out in desiccators in which constant relative humidity was maintained by sulphuric acid solution after the method of Wilson (1921). At the conclusion of each experiment the specific gravity of the sulphuric acid solution was tested. The variation in relative humidity was usually within two to three per cent of the initial value. All materials used as culture media were conditioned by exposure in thin layers in open petri dishes over sulphuric acid in desiccators for two weeks. The contents of each dish were thoroughly mixed daily to establish equilibrium with the humidity and temperature.

Two hundred individuals were used in each experiment. Chapman (1919, 1924) has shown that excessive handling retards the rate of development and increases mortality. Therefore the cultures were examined daily at or near the pupal stage to reduce handling to a minimum. Stanley (1938) observed that, except on a highly nutritious food, egg eating has a deleterious effect on oviposition. The cultures were therefore sifted daily for eggs to minimize loss in this way.

Eggs were secured from a large number of adults reared on second patent flour in large shallow pans maintained at the temperature at which the tests were to be run. Preliminary tests indicated that the disturbance caused by removing the insects from the flour during the sifting for eggs resulted in few eggs being laid during the first hour after their return to the flour. The adults were therefore left in the flour for three hours and very satisfactory oviposition occurred during this period. For purposes of computation the end of the second hour was chosen by experiment as the time when the eggs were deposited.

The duration of the egg stage was determined by the use of an interval-timer (Gray, 1946). This device provided a means of determining the hatching time on a hourly basis or at shorter intervals if desired. Aside from the setting, and the winding of the clock mechanism, the operation was automatic, and the counting could all be done at one time at the conclusion of the hatching. The success of this device depends upon the habit of the newly hatched larvae of *T. confusum* of crawling through the wire screen. After the thorax has passed through, the larva is unable to support itself and falls to the greased recording chart below.

Two hundred first-instar larvae from parents reared on 0 per cent wheat germ in second patent flour were placed in each culture medium, namely, 0,  $\frac{1}{2}$ , 2, and 5 per cent wheat germ in second patent flour, as represented in Table 1 by 1, 2, 3, and 4 respectively. First-instar larvae of the next generation were then transferred independently to each of the media, giving 16 further cultures (e.g., 1 represents the parental generation of 1A, 1B, 1C, and 1D). The rate of development from the time the eggs were laid to the emergence of the adults was recorded in each case. The sexes were noted, but since they showed no significant difference in rate of development males and females are not separated in the summaries.

Table 1

RATES OF DEVELOPMENT OF PARENTS AND OFFSPRING OF *TRIBOLIUM CONFUSUM*  
 DUV. REARED ON DIFFERENT PERCENTAGES OF WHEAT GERM IN SECOND  
 PATENT FLOUR

Expt. No.	Percentage of Wheat Germ in second Patent Flour		Development			Total	Mortality %
	Food of parent larvae and adults	Food of offspring	Average of period, days				
			Larva	Pupa	Eggs		
1*	0	0	18.87	5.64	4.24	28.75	8.5
1A	0	0	18.84	5.52	4.21	28.60	10.5
1B	0	½	19.14**	5.46	4.19	28.84	7.0
1C	0	2	19.36**	5.49	4.26	29.09	13.0
1D	0	5	16.52	5.45	4.12	26.21	6.5
2*	0	½	17.65	5.55	4.14	27.44	10.0
2A	½	0	18.54	5.54	4.15	28.22	12.0
2B	½	½	17.51	5.52	4.18	27.17	7.5
2C	½	2	17.38	5.50	4.12	27.02	7.0
2D	½	5	16.48	5.49	4.11	26.11	6.0
3*	0	2	17.81	5.55	4.17	27.60	8.5
3A	2	0	18.28	5.61	4.25	28.06	5.0
3B	2	½	17.27	5.65	4.19	27.09	7.5
3C	2	2	16.83	5.56	4.21	26.56	6.5
3D	2	5	16.63	5.48	4.13	26.28	2.5
4*	0	5	17.25	5.66	4.23	27.15	11.0
4A	5	0	17.95	5.48	4.22	27.66	6.0
4B	5	½	17.38	5.46	4.19	27.07	9.5
4C	5	2	16.89	5.39	4.15	26.51	11.0
4D	5	5	16.43	5.47	4.11	26.13	3.5

\*1, 2, 3, and 4 represent four lots of 200 individuals from parents reared on 0 per cent wheat germ in second patent flour. 1A, 1B, 1C, and 1D represent the offspring of 1, etc.

\*\*These figures are not included in the analysis since mould invaded the cultures before development was complete.

Fisher's *t* test was used to compare the results, and Table 2 shows the values of *t* for comparisons made in the text.

Table 2

VALUES OF *t* FOR COMPARISONS MADE IN TEXT BETWEEN AVERAGE LARVAL  
 PERIODS IN TABLE 1

Expt.	1A	1D	2A	2B	2D	3A	3C	4A
1D	14.7**							
2D		.33	13.7**					
3D						12.9**		
4B				.94				
4C							.42	
4D					.5			11.9**

## RESULTS AND DISCUSSION

The results of these experiments indicate that parental food does not affect the rate of development of offspring of the confused flour beetle. Whether parents were reared on a diet containing a low or a high percentage of wheat germ, the rate of development of offspring was dependent on the percentage of wheat germ in the diet on which the offspring were reared. Larvae developed at a greater rate when they were reared on 5 per cent wheat germ than they did when reared on 0 per cent, regardless of whether their parents had been reared on 0 per cent (compare 1A and 1D),  $\frac{1}{2}$  per cent (compare 2A and 2D), 2 per cent (compare 3A and 3D), or 5 per cent (compare 4A and 4D). Offspring reared on the same diets developed at approximately the same rate whatever the diets on which their parents had been reared (compare 1D and 2D, 2B and 4B, 3C and 4C, 2D and 4D).

In experiments on two other insects infesting stored products, the cigarette beetle, *Lasioderma serricorne* (F.), and the drug-store beetle, *Stegobium paniceum* (L.), Fraenkel and Blewett (1943) found that they would develop normally on diets in which other stored product insects would not. This difference was attributed to the presence of intracellular symbionts which supplied the necessary vitamins for growth. It is, therefore, possible that micro-organisms present in the species used by Reynolds contained sufficient vitamins to enable the offspring to develop at an increased rate during the early immature stages. This may account, in part, for the difference in results. Reynolds, however, suggests that the parental food affects the offsprings in a physiological manner, rather than by the genetic inheritance of food preference, and that the nutritive value of the yolk is partly responsible for this acceleration. No experiments were conducted to show that this is likely.

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## A STUDY OF TURNIP ROOT MAGGOTS IN ONTARIO

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For more than fifty years, entomologists in the United States, Great Britain and Canada have studied the maggots that infest cruciferous crops. Out of their work have come control measures beneficial to the grower of radishes, cabbages and cauliflowers. Nothing, however, has yet been found of much use in connection with turnips (rutabagas) — a crop of some importance in Ontario and in eastern Canada.



Herein is reported part of the studies on turnip root maggots carried on at the Ontario Agricultural College in 1950 and 1951. Seasonal changes in the numbers of maggots infesting turnips are recorded and methods of comparing the root damage caused by these pests are discussed. It is hoped that this information will provide data of value for others in arriving at some practical means of control.

### Methods

Two farms were studied in 1950; and two different ones in 1951. It would have been better to have used the same two throughout but this was not possible. All four farmers had grown this crop previously. The variety used in each instance was Laurentian.

Table I

#### CERTAIN DATA ON THE FOUR ONTARIO FARMS USED IN THIS SURVEY

Year	Farm	County	Area of field used	Sowing time	Harvest started	Remarks
1950	A	Wentworth	Plot in field	May 24	—	The first planting was disked up and re-sown; a small plot was left for our use. The surrounding field was sprayed once with parathion.*
1950	B	Wentworth	2 acres	May 31	mid Oct.	One (or two?) sprays of parathion and DDT.*
1951	C	Oxford	2 acres	June 1	early Sept.	No insecticide used.
1951	D	Wellington	4 acres	May 19	Aug. 30	Two parathion sprays (for flea beetle control) in early June.*

Samples of turnips (generally 50 roots per field per week) were obtained periodically from each field. The roots were taken at equal intervals along diagonal lines running across the field. The turnips were brought back to the laboratory where they were measured, examined, peeled and sliced. All maggots found were preserved for later identification and enumeration. During the second year more detailed records were kept of the weather and of surface root injury.

### Root Maggot Fauna

The larvae of three species of the family Anthomyiidae were found commonly in turnips. *Hylemya brassicae* Bouché, the cabbage maggot, was the dominant species and the main cause of economic damage to the turnip crop. It has received most attention in this report. *Hylemya cilicrura* (Rond.), the seed corn maggot, and *Hylemya trichodactyla* (Rond.) are treated as one species complex in this paper, since only adult males of the latter two species could be separated by the present author.

The larvae of *H. cilicrura-trichodactyla* were relatively abundant in June and July. They caused some economic loss, either by destroying seedlings or by disturbing the root system.

\*All sprays were applied by the farmer. It was impossible to get exact details. Approximately 1 lb. of parathion (15% w.p.) was applied per acre in A, B, and D in 80-100 gallons of water. In addition on farm B approximately 1 lb. of DDT (50% w.p.) was included in the spray per acre.

Table II

THE RELATIVE ABUNDANCE OF LARVAE OF *H. CILICRURA-TRICHODACTYLA* EXPRESSED AS A PERCENTAGE OF THE TOTAL NUMBER OF ROOT MAGGOTS; THE REMAINDER IS *H. BRASSICAE*.

Months	Farm A	Farm B	Farm C	Farm D
June & July	29	62	35	35
August	18	16	0	0.3
Sept. & Oct.	No sample	0.6	0	0.8

Table III

THE AVERAGE NUMBERS OF LARVAE OF *H. CILICRURA-TRICHODACTYLA* PER SAMPLE OF 50 TURNIP ROOTS

Months	Farm A	Farm B	Farm C	Farm D
June	25.0	0	0	0
July	28.5	59.0	26.6	23.5
August	5.3	23.5	0	0.8
September	no sample	1.0	0	2.6
October	no sample	0	0	1.0

Brooks (1951) stated that "On cruciferous plants the maggots [of *H. cilicruca-trichodactyla*] begin to appear late in June, becoming common in August. After the middle of September, very few specimens of *cilicruca* or *trichodactyla* can be found on these hosts."

As may be seen from Tables II and III, the results from the four Ontario farms do not agree with this statement. Both relative to *H. brassicae* and from the standpoint of absolute numbers, the seed corn maggots were most abundant in July.

#### Population Curves (Graphs 1 and 2)

##### Description

There were moderate numbers of larvae of *H. brassicae* present in the early season. In A, C and D, these were smaller in early August. Thereafter A & C remained small, while B and D rose to seasonal maxima, dropping in September and October.

##### Validity

In order to obtain valid figures to represent a standing population of such insects it is necessary to have adequate sampling, both of the host plant — turnip, and of the root maggots.

The root sampling, although not strictly random in nature, was good enough for the purpose, I believe. As for sampling the maggots — it was possible to obtain all or nearly all of the larger third instar maggots from the roots. Many of the first and second instar maggots, which are quite small, were probably overlooked. As the same two workers collected these maggots in 1950, and 1951, it was expected that the resulting figures were of comparable value. The absolute populations of root maggots in the four fields under investigation would, of course, be greater still.

*Interpretation of curves*

These graphs represent the net gain by recruitment of new larvae which have hatched from freshly deposited eggs, over losses incurred by predation and disease and still more by maturing and consequent emigration out of the root into the soil in order to pupate.

As far as we know at present, the major natural losses in the life cycle occur in the egg stage (mite and beetle predation?) and in the puparial stage (largely caused by a staphylinid parasite). Mortality during the three larval stages represented in the curves would seem to be slight.

Why are there, in the case of B and D, great numbers in the late season but not in the case of A and C? Perhaps A should be ruled out of our immediate argument since it was a very small plot saved out of a larger field. Two features concerning D may go part way in attempting an explanation of its great maggot population. The two parathion sprays used in early season may have upset its maggot-predator-parasite balance. It was slightly more distant from other turnip fields, than was C, or in fact A or B.

Clearly cut broods are not shown by these curves. There is a suggestion of two broods occurring on turnips — one in early season on all four and one in late season on B and D, but failing to develop in A or C.

*Root maggot damage to turnips*

From Table IV and from Figures 1 and 2 some idea of the scarring and burrowing in turnips caused by the three species of root maggots may be obtained. By harvest time, in fact, it was difficult to find in this field a turnip unaffected by maggots. On the average, by Aug. 30, one sixth of the turnip-surface had been scarred.

Table IV

## FARM D: MAGGOTS AND THEIR DAMAGE TO EARLY TURNIPS

Date (1951)	Aver. diam. of root in inches	Aver. no. of root maggot burrows per turnip	Aver. % surface area injured by maggots	% no. of turnips injured by maggots	Aver. no. of maggots (all spp.) per turnip	Remarks
June 15	1/16		not recorded	6	.16	
20	1/8	0	0	0	0	
27	1/4		not recorded	24	.04	
July 5	1/2		not recorded	34	1.2	
12	1	2.4	6.1	62	1.1	
19	2	3.4	12.6	70	0.5	
26	2-3/4	3.4	18.8	86	1.0	See photo
Aug. 2	3-1/2	3.8	13.9	88	0.4	
9	3-3/4	3.2	17.0	84	0.2	
16	3-3/4	6.0	16.9	92	3.1	
23	4-1/4	12.9	14.0	100	9.5	See photo
30	5	16.3	16.6	98	13.1	Harvesting started



### Discussion

In determining the efficacy of root maggot control given by an insecticide, it is necessary to use some index which somehow enumerates the root maggots or their effects. Such an index should be easy to obtain and to standardize and should convey a great deal of information.

To consider a hypothetical case (see Table V): If we had decided to use an insecticide to control the late season population (the economically important phase) of maggots on Farm D in 1951, we might have applied our insecticide on July 12. This is the way the results for our check would have appeared.

Table V  
HYPOTHETICAL EXAMPLE FARM D

Date (1951)	Aver. no. of root maggot burrows per turnip	Aver. % area of root injury by maggots	% no. of turnips injured by maggots	Aver. no. of maggots (all spp.) per root
July 12	2.4	6.1	62	1.1
Aug. 30	16.3	16.6	98	13.1
Ratio of increase	6.8	2.7	1.6	11.9

The two most expressive indices — number of burrows and of maggots — are the most difficult to obtain and to standardize. The other two indices are easier to arrive at and to standardize but they do not give as much information. This is especially so if there are many young maggots present. These do not cause easily detectable surface damage, yet they are economically important.

### SUMMARY

Larvae of three species of anthomyiids caused damage to turnips in Ontario. Two of them, the seed corn maggots, *H. cilicrura* and *H. trichodactyla*, injured roots in early season. The other species, the cabbage root maggot, *H. brassicae*, was prevalent throughout the growing period. It may cause great economic loss at harvest time. The standing populations varied greatly. There tended to be early season minor peaks followed by either a greater peak or a recession. The effects of sprays and isolation were surmised. Estimates of the root maggot injury to the turnips on farm D were given in different forms. It was suggested that the number of burrows or of maggots offered the most sensitive index for evaluating the efficacy of controls.

### ACKNOWLEDGMENT

Help was received from Professor A. W. Baker, Mr. R. W. Walsh and the four co-operating farmers.

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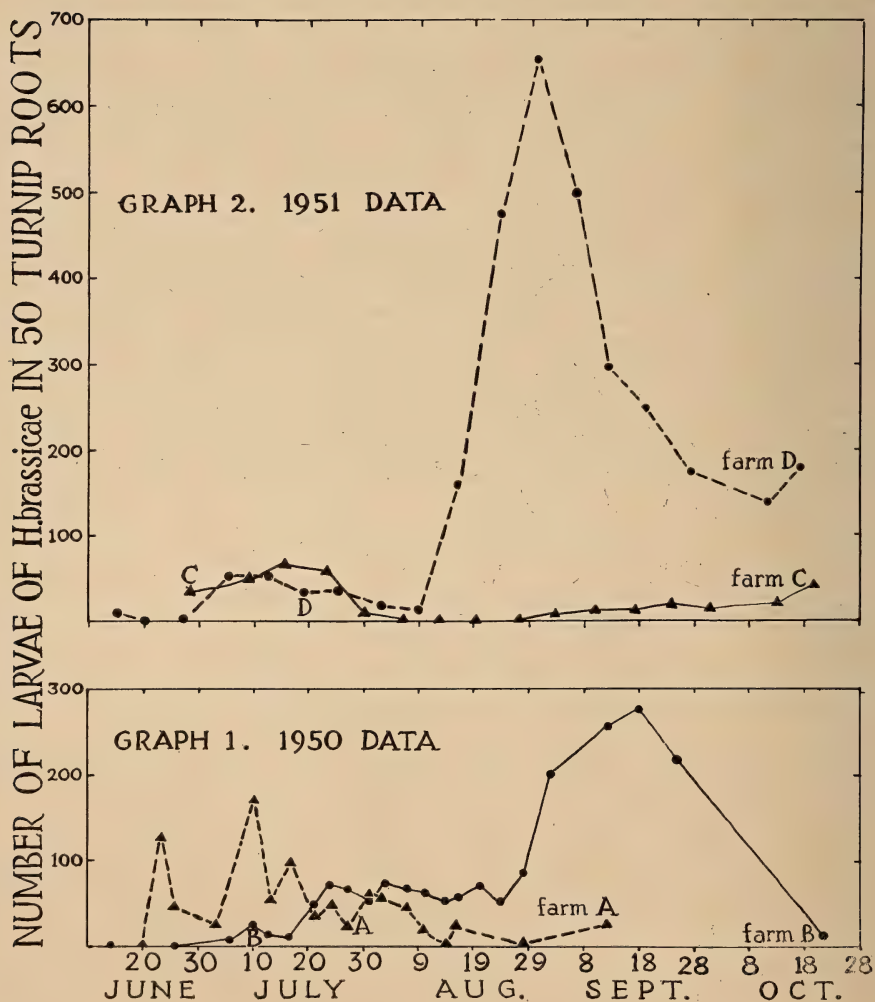
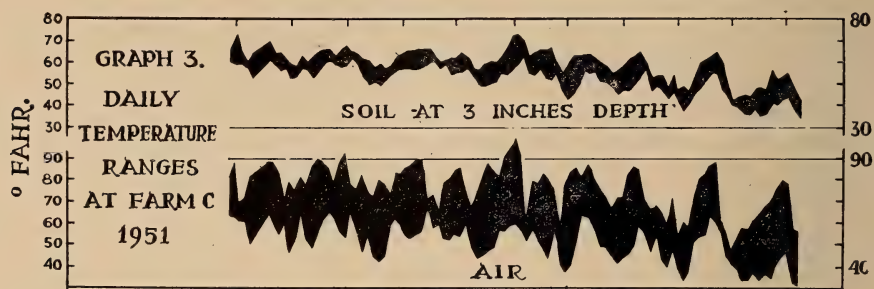




Fig. 2. Injury to turnip caused by root maggots. The root has been cut in half. Farm D, August 23, 1951. 7 burrows, 10% of area affected; diameter  $5\frac{1}{4}$  inches.





Fig. 1. 2A 5 burrows, 7% of area affected;  
2B 5 burrows, 15% of area affected;  
2C 22 burrows, 75% of area affected;  
range of diameters;  $2\frac{1}{2}$  to 3 inches.

Injury to turnips caused by root maggots. Each turnip has been cut in half.  
Farm D, July 26, 1951.

## THE EFFECT OF DDT SPRAY APPLICATIONS ON ALSIKE SEED PRODUCTION IN SOUTHERN ONTARIO\*

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The entomological aspects of alsike seed production were given consideration by the Legume Research Committee in Ontario first in 1948. Earlier, Arnott (1948), formerly of the Field Crop Insect Laboratory, Chatham, had made a preliminary survey of the problem and to him should go the credit for discovering the major insect pest of the crop and for much of our knowledge of its biology. The 1948-1949 findings were published by Pielou (1950), now of the Dominion Parasite Laboratory, Belleville. The present report is concerned with studies conducted during 1950 and 1951.

The principal insect involved is *Tychius picirostris* Fab., a curculionid immigrant from Europe. The feeding activities of both the adults and larvae reduce seed production. There is only one generation each year and by alsike harvest-time adult weevils, which will overwinter, are beginning to emerge from the soil. No parasites or predators of the insect have been reported. Other insects and particularly spittlebugs (two varieties of one species of *Philaenus*) no doubt affect seed formation and maturation.

Pielou tested a number of different insecticides in dust and spray form. He concluded that DDT, as a spray, because of its effectiveness with *Tychius* and its lack of toxicity to honey bees, offered the most promise. It still does, although the value of a number of other materials should be investigated.

**EQUIPMENT AND METHOD.** 1950. — The experiments involved replicated ¼-acre plots (W. F. Keith farm, eastern Norfolk County), and a field test (H. A. Porter farm, central Haldimand County) of greater acreage. In all, 20 long narrow randomly arranged plots were laid out in 4 blocks of 5, in a uniform volunteer stand of alsike (Keith). This plan was convenient for tractor-drawn equipment, and damage by turning, to the alsike surrounding the area, was reduced to a minimum. The field test (Porter) comprised a long (770 yards), narrow (40 yards) piece of seeded alsike with an area of approximately 7 acres. The growth was quite even at both ends of the field but toward the centre it had thinned out somewhat due to winter damage.

DDT (50% wettable powder) was applied as accurately as possible at the rate of 1 lb. actual DDT per acre in 80 gallons of water. Applications were made with a tractor-drawn power sprayer (Farquhar Iron Age) equipped with a 1¾ h.p. pump, a 100-gallon tank, and a 15-foot long, height-adjustable, 11-nozzle boom. A pressure of approximately 100 lbs. was employed. The tank capacity permitted the spraying of 4 similar plots (1 in each block) with one filling. Treatments were applied in late afternoon or early evening when pollinating insects were not active.

On the Keith plots, the sprays were applied as follows:

Treatment No.

1. Two applications, June 5, and 19.
2. One application, June 13.
3. Check.
4. Two applications, June 5 and 19.
5. Two applications, June 2 and 13.

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\* Part of the Programme of the Legume Research Committee in Ontario.

The Porter alsike was sprayed twice, June 6 and 17. The first open florets were noticed on June 2. On June 16, *Tychius* counts per 100 net sweeps in untreated alsike were almost 1,700, indicating a considerably higher population than in the Keith alsike.

1951. — Field rather than replicated plot tests were conducted. The locations, acreages, spraying dates and the amounts of DDT used, are given in Table I. The same equipment, pressure, etc., as employed in 1950, were used in spray applications. Untreated areas, adequate in size and location, were left for comparisons. No spraying was done until the fields were at least at the half-bloom stage and until sizable weevil populations were present.

Table I  
EXPERIMENTAL ALSIKE FIELDS 1951

Farm	County	Acreage	Date of Treatments	Insecticide DDT (50% w.p.)
Keith	Norfolk	5.14 volunteer	1. June 11-12 2. June 18	1 lb. actual/ac.
Mowat	Haldimand	5.5 volunteer	1. June 15	1 lb. actual/ac.
Fallis	Haldimand	4.0 volunteer	1. June 14 2. June 25	1 lb. actual/ac.

The seasonal *Tychius* populations in the fields varied considerably. The Keith field supported the largest numbers. On June 16, 100 net sweeps in untreated alsike contained 2,856 adult weevils. The Fallis alsike had a population approximately half and the Mowat field about one-fifth as great.

POLLINATING INSECTS. — The records of the Apiculture Department indicated that 100 or more colonies of honey bees were located between  $\frac{3}{4}$  and  $1\frac{1}{2}$  miles of the Keith alsike. In 1950, these bees, along with wild pollinators, effected a substantial seed-set. In order to obtain maximum pollination in 1951, 20 colonies of bees were placed in the alsike close to the eastern end of one of the Keith check plots. Square yard counts of bees were made at intervals by the Apiculture Department. These were consistently lower\* than in the Keith 1950 alsike when no bee colonies were in the field. Repeatedly, bees were observed leaving and coming in to the colonies at heights greater than necessary to work the surrounding alsike. Obviously, they had more productive nectar or pollen sources elsewhere, — probably yellow and white sweet clovers which were almost ubiquitous during the summer. Only on 1 or 2 days did the field honey bee population approach that of the previous year.

DDT AND REDUCTION OF *TYCHIUS* POPULATIONS IN KEITH ALSIKE. — In the 1948-1949 tests (Pielou, 1950), the timing of spray applications was determined by the amount of bloom in the fields, irrespective of the *Tychius* populations. His conclusion was that "DDT applications were most effective if applied in the bud stage before appreciable blossom had appeared". This timing plan was followed, with some modification, in 1950. Daily sweeps (50 per plot) with a standard insect net indicated, however, that few weevils were present in the alsike before blossoming was well started. Until June 11, the *Tychius* population was negligible but on that day movement in numbers into the crop from fencerows, woodlots and pastures began. The first opened florets were observed on June 2 and by June 12, it was estimated that the plots were from half to three-quarters in bloom.

The first spray applications, June 2 and 5, were largely wasted (Fig. 1) as very few *Tychius* were present. Any residual effect was not evident when the weevils began to move into the alsike. The later sprays, June 13 and 19, markedly reduced populations for about a week. These

\* 67 bees per 100 sq. yds. as compared to 90 in 1950 (Apiculture Department figures).



reductions would have been more pronounced, perhaps, had the movement of new weevils into the crop not been so rapid. When population increases in the sprayed plots began again, they proceeded somewhat more slowly than in untreated areas. Population peaks for the check and sprayed (June 13) plots came at the same time, July 4. Peaks for the June 19 sprayed plots were reached about 5 days later. Following the attainment of the peaks, decline in all plots proceeded rapidly until the crop was harvested.

## 1950 EFFECT OF DDT ON ADULT POPULATIONS OF *TYCHIVS PICIROSTRIS* KEITH ALSIKE

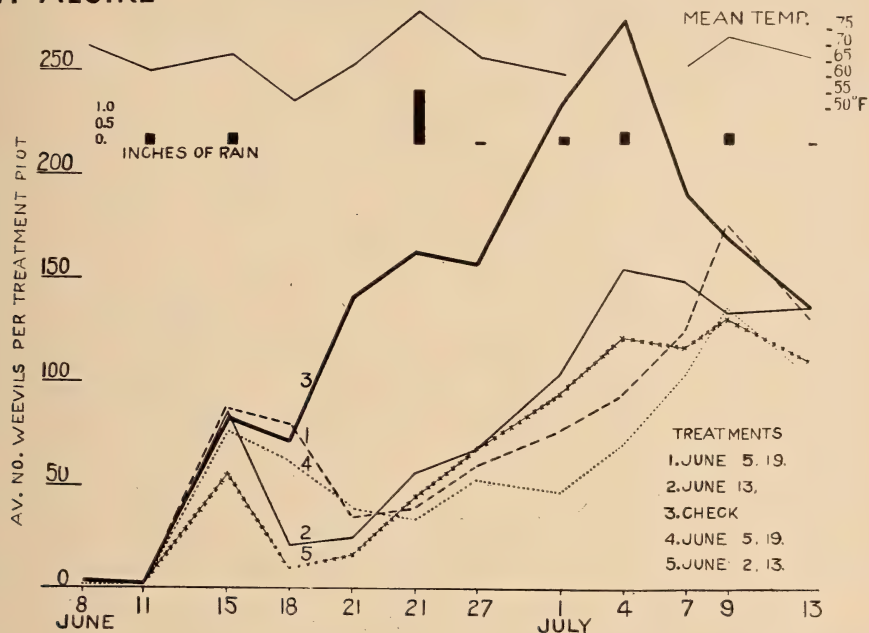


Fig. 1. Effect of DDT applications on populations of *Tychius picirostris* in alsike clover. Norfolk County, 1950. Weather data are shown.\*

In 1951 on the same farm, the first weevils were taken in the alsike on June 4 but a general migration into the crop did not begin until June 10 and 11 (Fig. 2). The first spray was applied on June 11-12 and the second on June 18.

At the time of the first spray, weevil counts per 100 net sweeps averaged 1,250. By June 14, these were down to 275. The population began to increase rapidly again because of the continued movement of new *Tychius* into the plots and when the second treatment was given, counts of almost 900 weevils were obtained. By June 20, the population in treated plots had reduced to 50. Throughout the remainder of the growing period, the numbers of weevils in the treated plots remained low, never reaching 200 per 100 sweeps until early in July when there were several temporary higher peaks. The author feels that the sprays were well timed for maximum weevil control. The greatest population found in untreated alsike was reached on June 16, when more than 2,900 weevils were taken in 100 sweeps. From that date the population, with minor fluctuations, gradually dropped until at harvest time approximately 425 were still present. It is quite possible that some of that number were newly emerged adults of the next generation.

\* Prepared by D. A. Arnott from daily sweep count totals from Keith field.

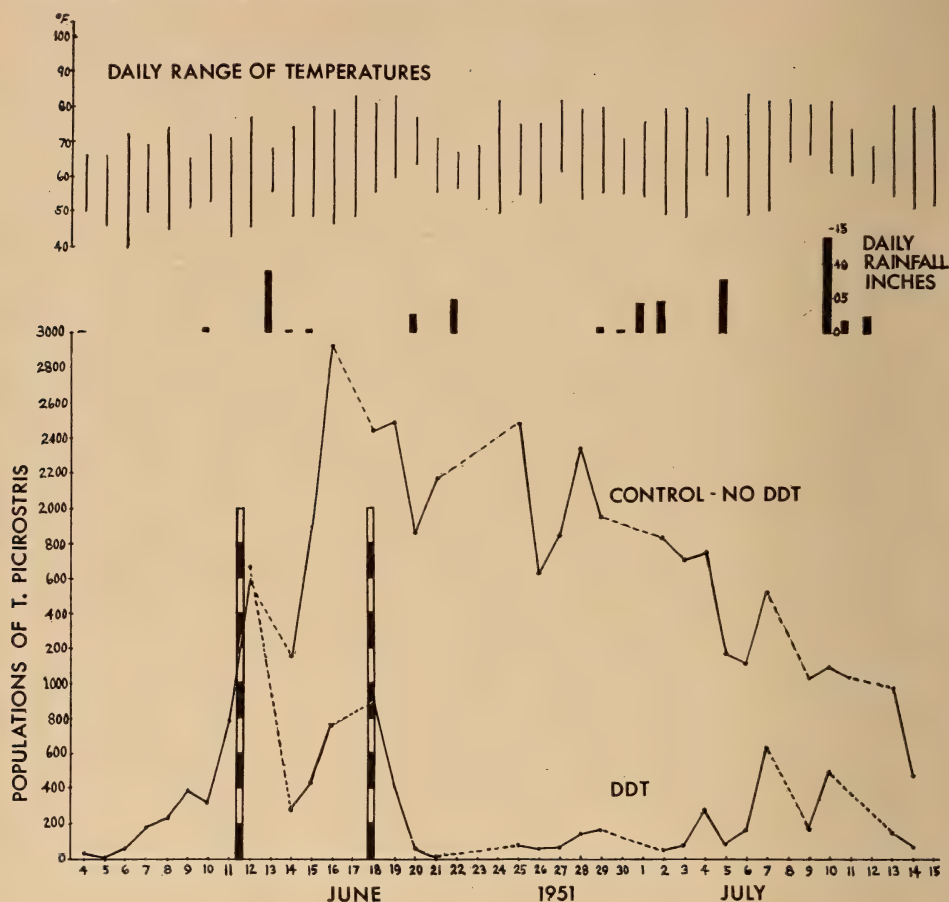


Fig. 2. Effect of DDT applications on populations of *Tychius picirostris* in alsike clover. Norfolk County, 1951. Weather data are shown. Dotted portions of the curves indicate that no sweeps were taken on those days.

SEED YIELD IN RELATION TO DDT SPRAYS. — Shortly before harvesting began, a number\* of square yard samples (Table II) were taken at random from each plot by the Field Husbandry Department. The entire plants were cut just above ground level, bagged, dried, and

Table II

NO. OF SAMPLES TAKEN FOR THEORETICAL SEED YIELD CALCULATIONS

Place	Year	Size of plots	No. of quadrats taken per plot
Keith	1950	.25 ac.	6
Porter	1950	2.0 ac.	10
		1.2 ac. Check	
Keith	1951	1.48 ac.	15
		1.09 ac. Check	
Fallis	1951	.6 ac.	10
Mowat	1951	1.23 ac.	10

\* Considered adequate by the Field Husbandry Dept. for areas involved.

subsequently threshed and cleaned. Threshing was accomplished by putting each sample through a Kemp small-grain thresher and the stover (straw) through a homemade scarifier; cleaning by means of a fanning mill. The estimated per acre yields of clean seed obtained from the 1950 and 1951 experiments are shown in Fig. 3.

In both years, the sprayed plot yields were highly significantly greater than the unsprayed. It is evident after an examination of Fig. 3 that a greater number of factors favourable to seed-set, were operating in 1950 than in 1951. The spring in 1951 was late, cool and moist and throughout the alsike growing period there was more moisture and generally lower temperatures than in 1950. Vegetative growth was marked and some lodging occurred. Another factor which undoubtedly interfered with seed-set was the great abundance of the sweet clovers. Honey bees and perhaps other pollinators, seemed to find the yellow and white sweet clovers much more attractive as pollen and nectar sources.

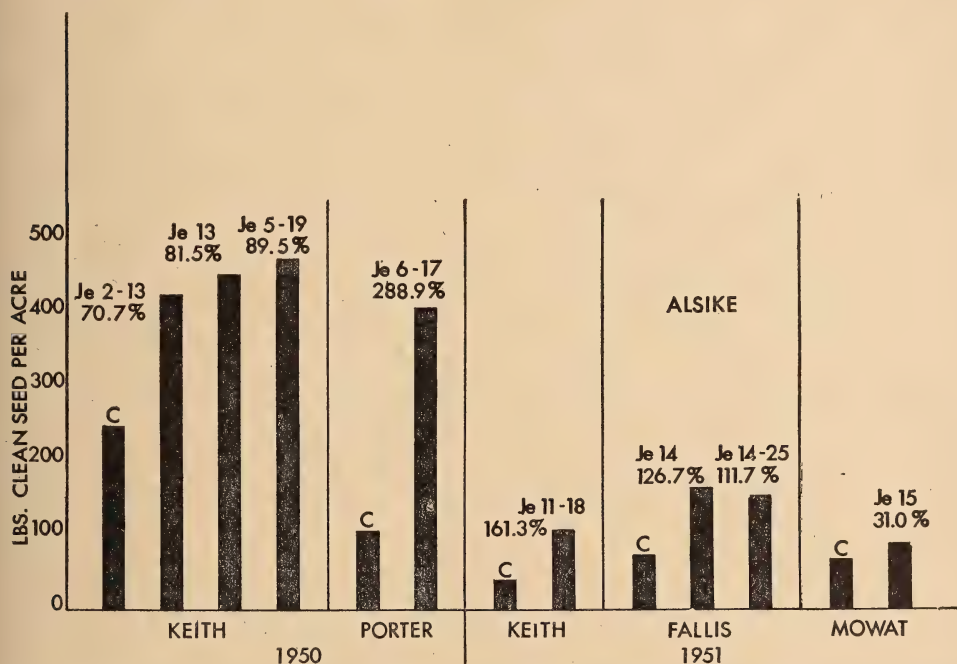


Fig. 3. Seed yields from sprayed and unsprayed alsike in 1950 and 1951. Spraying dates are given and the increased yields due to spraying are shown graphically and as percentages. "C" in each case indicates check yields.

It is interesting to note that, as mentioned earlier, the *Tychius* population in the Porter (1950) was much larger than in the Keith alsike. This is reflected in the much lower check yield at Porter's and in the much greater increase in yield from sprayed plots.

The differences between the treatments at the Keith farm (1950) and at Fallis' (1951), where it would seem that one spray gave better protection than two, are interesting although not significant.

While insecticidal treatments in 1951 did give a percentage increase comparable with those of 1950, the practical value of these increases was such that it probably would not have paid the growers to spray.

**GROWERS' SEED LOSSES AT HARVEST.** — In Table III a comparison between actual and theoretical yields of seed is given for the 1950 experimental areas.



Table III

## SEED LOSSES AT HARVEST, JARVIS AND CAYUGA, 1950

Place	Acreage	Harvest procedure	Actual yield	Calculated yield if acreage unsprayed and no harvest loss	Calculated yield of sprayed & unsprayed acreage if no harvest loss
Keith	21 4 sprayed	Mower-cut Cocked Stationary Dion Thresher	53 bu. $\pm$	87 bu. $\pm$	101 bu. $\pm$
Porter	6.4 4.0 sprayed	Mower-cut & windrowed Pick-up combined	15 bu. $\pm$	11 bu. $\pm$	31 bu. $\pm$

At both farms, seed losses at harvest, because of adverse weather conditions after cutting, inefficient harvesting machinery or techniques, were in the neighbourhood of 50 per cent. Part of the Keith acreage was experimentally harvested and his smaller field (6 ac.), for unknown reasons, did not set nearly as much seed as the 15-acre field which was not more than 100 yards distant. Thus, his loss at harvest was, perhaps, not as great as it would appear. Rain delayed the drying-out of the windrowed Porter crop and part of the windrows had to be turned. Both factors would increase shelling considerably.

**SUMMARY.** — 1. Under some conditions honey bees prefer sweet clover or other plants to alsike as pollen or nectar sources and consequently the recommended numbers of honey bee colonies in an alsike field will not, necessarily, insure a good seed-set.

2. DDT (50% w.p.) as a spray, applied at the proper time(s), at the rate of 1 lb. actual DDT per acre will control the adults of *Tychius picirostris* so that, other factors being favourable, satisfactory seed yields can be obtained.

3. The weevils do not migrate in large numbers into the alsike until there is considerable bloom present. Treatment consists of two applications. The first should be applied at the "half-bloom" and the second 8 to 10 days later. If only one insecticidal treatment is possible, it should be made from 5 to 7 days after the "half-bloom" period. "Half-bloom" is difficult to determine and it may vary from year to year. A more accurate description would be when from 10 to 15 alsike heads in every square yard show some brown basal florets, indicating that fertilization has been effected and seed development is taking place.

4. Increases in seed yield following DDT treatment(s) varied from 31 to 289 per cent, the yields varying from 1.5 to 8 bushels per acre. 1950 was a better alsike seed year than 1951. Even with increases in yield as much as 161 per cent in 1951, the best yields were less than 200 lbs. of clean seed per acre.

5. Growers' seed losses at harvest in 1950, because of adverse weather conditions and inefficient harvesting methods or machinery, amounted to approximately 50 per cent.

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## SUMMARY OF THE MORE IMPORTANT INSECT INFESTATIONS AND OCCURRENCES IN CANADA IN 1951<sup>1</sup>

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This summary of insect conditions has been prepared from regional reports submitted by officers of the Division of Entomology, provincial entomologists, officers of the Division of Plant Protection, and university professors. In general, common names used are from the April, 1950 revision of the list approved by the American Association of Economic Entomologists. Common names other than these are accompanied by technical names. To avoid unnecessary duplication, forest insect conditions are not included, this insect group being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey, 1951*, published by the Division of Forest Biology, Canada Department of Agriculture.

Information on weather conditions was obtained from reports submitted by officers of the Division of Entomology and from provincial crop reports. The crop production summary was taken from the "November Estimate of Production of Principal Field Crops, 1951", Dominion Bureau of Statistics, with data revised to agree with the Bureau's "Revised Estimate", Feb. 21, 1952. Data for Newfoundland were not available.

### SUMMARY OF WEATHER CONDITIONS IN CANADA IN 1951

In British Columbia there was very little rain during the growing season of 1951. In the spring, hot and cool spells alternated but cool weather predominated, retarding growth to some extent. July was slightly hotter than average, August cooler, and September normal. The temperatures for the season as a whole were somewhat below the long-term average.

In Alberta, the season was unusually late and seeding was delayed. Rains were frequent, particularly in northern and southern to southwestern areas, but came too late in the south-east to help crops that matured too rapidly. Pastures were generally good but much hay was spoiled by excessive moisture, and in southern areas there was considerable sprouting of grain in swath and stook. Seed alfalfa was very poor. Severe frosts late in September, following the

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heavy precipitation, seriously affected the quality of most crops, and a large acreage was not harvested. In Saskatchewan, too, seeding was delayed; but surface moisture was abundant and growth was excellent. Subnormal rainfall prevailed generally throughout May and June but, as the temperatures were subnormal, there was little crop deterioration. The weather was wet and cool throughout the remainder of the summer, delaying the maturing and harvesting of crops to such a degree that, as in Alberta, the crop remained unharvested in many districts, and the quality of harvested grain was low. In Manitoba, seeding was late and a severe drought occurred from May until mid-August. The period from April 1 to July 31 was the driest since 1897. A good moisture reserve and cool weather until the third week of July prevented a crop failure. Germination, however, was spotty and gardens were very poor. Hot weather with temperatures up to 103° F. caused severe burning of crops and pastures. As in Alberta and Saskatchewan, cool, wet weather throughout the fall seriously delayed harvesting and resulted in much sprouting and bleaching of grain, but pastures were restored to good condition. Weather conditions in the Prairie Provinces held grasshopper damage to a minimum generally. Wireworm damage was reduced in Saskatchewan, but damage by the pale western cutworm increased. Cool weather and a lack of southerly winds reduced outbreaks of migrating and wind-dispersed insects to a minimum.

In Ontario and Quebec, overwintering conditions for crops were good. April was wet and seeding was delayed but by the end of May it was nearing completion in most areas. Except in some northern districts, rainfall was generally abundant in June and July, promoting excellent growth of all crops except beans, corn, roots, and buckwheat, all of which, in some areas, required more heat. Haying operations, however, were greatly hampered by the frequent rains, so that much hay spoiled and much that was saved was of poor quality. Grain harvesting also was delayed by rains, especially in eastern and northern Ontario and in Quebec. Yields were good to excellent but considerable discolouration occurred, and in northern Ontario much grain was not harvested. Pastures were fair in southwestern Ontario and good to excellent elsewhere. New hay seedings developed well, but considerable rot developed in potatoes and tomatoes.

In the Maritimes, spring growth was good but cold weather prevailed in northern and eastern Nova Scotia. Seeding was delayed by frequent rains in some areas and there was some frost damage to tender fruits. Frequent rains continued throughout the season, promoting excellent growth except in parts of Nova Scotia and Prince Edward Island, where excessive moisture retarded grains. Haying operations were hampered but most of the crop was harvested. Pastures continued in excellent condition throughout the season. The apple crop in Nova Scotia and New Brunswick was lighter than in 1950, and much scab developed as a result of the dull, wet weather. There was considerable lodging of grains, harvesting was delayed, and some sprouting developed, but yields were about average. Some spoilage of late-cut hay occurred, and in New Brunswick potato blight was prevalent.

#### CROP PRODUCTION SUMMARY FOR CANADA, 1951

The estimated total acreage of field crops in 1951 was 64,049,000, compared with 62,297,000 in 1950. Production estimates for grain crops in Western Canada were subject to revision on the outcome of spring harvesting of wintered-over crops. Surveys showed the following estimated percentages of Western grain crops unharvested at December 31, 1951: wheat, 28 (150,000,000 bu.); oats and barley, 24 (134,600,000 bu.); flaxseed, 18 (1,552,000 bu.). New records were indicated for mixed grains and soybeans, and near-record crops of wheat, barley, hay, clover, and alfalfa were either in prospect or already realized.

**WHEAT.** — Canada's 1951 wheat crop, estimated at 562 million bushels, was slightly more than 100 million greater than in 1950 and second only to the record 567 million harvested in 1928. In the Prairie Provinces the wheat crop was placed at 531 million bushels as against 427 million for 1950 and the record of 545 million in 1928. However, realization of the estimate would be possible only if the unthreshed part of the crop remained in reasonably good condition and could be harvested without significant loss. Loss in grade was already evident from the effects of excessive moisture. However, it was anticipated that the proportion of milling grades would be considerably higher than in 1950.



**OATS.** — Production of oats in 1951 was placed at 493 million bushels, 73 million above that of 1950 and about 87 million above the ten-year (1941–1950) average. The 1951 crop was, however, well below the record 652 million bushels harvested in 1942. Though the oat crop in all provinces except the Maritimes and Manitoba was greater than in 1950, the most significant increases took place in Alberta and Saskatchewan.

**BARLEY.** — The 1951 barley crop, estimated at 253 million bushels, was only slightly below the record 259 million harvested in 1942 and exceeded the 1950 and ten-year average outturns by about 82 and 85 million bushels, respectively. Production exceeded that of 1950 in all provinces except Nova Scotia and Quebec, most of the increase, as for oats, occurring in Alberta and Saskatchewan.

**RYE.** — The combined production of fall and spring rye was placed at 18.0 million bushels, as against 13.3 million in 1950 and the average of 12.9 million for the preceding ten years. Slightly over half of the 1951 crop of rye was produced in Saskatchewan and approximately one-third in Alberta.

**OILSEEDS.** — With the exception of sunflower seed, the 1951 production of Canadian oilseeds for which estimates were available was well above 1950 levels. Production of flaxseed was placed at 9.2 million bushels as against 4.7 million for 1950 and the ten-year (1941–1950) average of 9.9 million. Soybean production, at 4.4 million bushels, reached a new peak and was approximately one million bushels greater than the previous record established in 1950. The rapeseed crop, estimated at 7.1 million pounds, was up sharply from 1950 as a result of substantial increases in both acreage and yield. Sunflower seed production, on the other hand, dropped from 9.9 million pounds in 1950 to 6.4 million in 1951 as a result of decreases in both acreage and yield.

**MIXED GRAINS.** — Production of mixed grains in 1951, though not quite as high as had been anticipated, set a new record at 80 million bushels. Ontario, with 59.1 million bushels, and Quebec with 12.6 million, accounted for the larger part of the 1951 record outturn.

**DRY PEAS AND BEANS.** — The 1951 outturns of dry peas and dry beans were slightly higher than in 1950, increased yields for both crops more than offsetting decreased acreages. Production of dry peas was estimated at 833,000 bushels as against 812,000 for 1950 and the outturn of dry beans was up from 1,350,000 bushels in 1950 to 1,378,000.

**SHELLED CORN.** — Production of shelled corn in 1951 was placed at 15.7 million bushels as against 13.8 million in 1950. Except for 135,000 bushels produced in Manitoba, where yields were unusually low, all of the 1951 crop was grown in Ontario.

**POTATOES.** — Decreased acreages in all provinces and smaller yields per acre in all but Manitoba and Saskatchewan sharply reduced the 1951 potato crop from the 1950 level. The 1951 crop, estimated at 67.2 million bushels *on the basis of field-run yields*, was almost one-third less than the 97.0 million bushels produced in 1950. In addition, fairly extensive after-harvest losses, ranging from 22 to 27 per cent, were anticipated in the Maritimes, one of the major areas of commercially grown potatoes. After-harvest losses were also expected to be fairly extensive in Ontario and Quebec.

**SUGAR BEETS.** — Production of sugar beets was estimated at slightly under one million tons, compared with the 1950 record 1.1 million. In Alberta, extremely unfavourable weather seriously interfered with lifting the crop, much of which was frozen and left in the ground.

**FORAGE CROPS.** — Production of hay, clover, and alfalfa in 1951 was at near-record levels but prolonged wet weather, particularly in Eastern Canada and Alberta, reduced quality considerably and caused some severe spoilage and abandonment. Consequently, the feeding quality of much of the estimated 17 million tons of hay and clover and 3.8 million tons of alfalfa grown in Canada in 1951 was lower than normal. Production of grain hay in 1951 was placed at 2.0 million tons, compared with 1.1 million in 1950.

**OTHER CROPS.** — The 1951 crop of fodder corn was placed at 5.1 million tons as against 6.4 million in 1950. Production of buckwheat, at slightly over 4 million bushels, was slightly higher than in 1950. The 1951 crop of field roots (turnips, mangels, etc.) for live-stock feed, excluding the Prairie Provinces, for which data were not currently available, was placed at 21.4 million hundredweight, compared with 23.1 million in 1950.

**HONEY PRODUCTION.** — The honey yield for 1951 was 40,909,000 pounds, an average of 101 pounds per colony, compared with 28,351,000 pounds, an average of 66 pounds per colony, in 1950. The yield was the third largest on record.

#### GENERAL-FEEDING AND MISCELLANEOUS INSECTS

**BEET WEBWORM.** — The beet webworm was of little importance as a pest in Alberta. In Saskatchewan it was more abundant than in 1950; infestations of adults and larvae were severe in west-central areas, particularly in the Demaine-Dunblane-Macrorie district, and light infestations were present throughout the Province, minor damage occurring on flax at Milden. In Manitoba, adult populations were greatly reduced as compared with 1950, and no damage was reported.

**BLISTER BEETLES.** — *Epicauta oregona* Horn. caused localized damage to potatoes and alfalfa in the Kamloops area of British Columbia, and injury to beets was reported from Cherry Creek. Blister beetles were more abundant than usual in northern Alberta; *Meloe angusticollis* Say commonly damaged clematis and occurred on potatoes, and *Lytta cyanipennis* (Lec.) was reported to have caused appreciable damage to flax in the Peace River district. In Saskatchewan, populations were the smallest in many years. *Lytta nuttallii* Say damaged caragana at Glenside; *Epicauta ferruginea* (Say) was reported from Davidson; *Meloe* sp. damaged clematis at Prince Albert, and occurred along with *Epicauta subglabra* (Fall) in a few alfalfa fields in the White Fox district. *Epicauta fabricii* (Lec.) and *E. subglabra* occurred in small numbers generally in Manitoba, but were abundant on caragana at Morden. *Epicauta pennsylvanica* (Deg.) was present only in small numbers in Prince Edward Island.

**CRICKETS.** — *Acheta assimilis* F., usually rare in the Agassiz area of British Columbia, was very numerous by the end of the summer, which was unusually dry. It was prevalent also in grain fields in the Vernon area. In Manitoba, the Mormon cricket and the field cricket were scarce, the latter feeding on corn at Gunton, and light infestations of the four-spotted tree cricket were reported from Brandon and Morden. The field cricket was scarce in Prince Edward Island.

**CHINCH BUGS.** — Populations of the chinch bug remained at a low level in Eastern Canada, but the false chinch bug was very abundant in roadside vegetation at scattered points in west-central Saskatchewan.

**CUTWORMS.** — A severe cutworm outbreak in the interior of British Columbia was considered the worst in 45 years. Most of the damage was caused by the red-backed cutworm, which, notwithstanding control measures, extensively damaged a wide range of vegetables and some field crops. Strawberries, raspberries, and small fruit trees were also injured. The black army cutworm damaged asparagus at Kamloops and barley at Prince George. The bertha armyworm occurred on potatoes at Kamloops, and was present in large numbers on alfalfa, potatoes, and garden crops in the vicinity of Soda Creek until mid-August, when it was almost completely destroyed by a virus disease. The black cutworm caused severe injury to sugar beet seedlings in the Ladner area.

In Alberta, severe infestations of the pale western cutworm occurred in localized areas, mainly at Armada, Enchant, Bow Island, Winnifred, Schuler, and Milk River. Damage was more extensive and severe than since 1946 and 1947, much early-sown grain being completely destroyed. The army cutworm caused minor losses in the Winnifred and Seven Persons districts, and the wheat head armyworm occurred in the lowest numbers in several years at Taber and Turin. The red-backed cutworm was absent in fields and gardens of northern Alberta despite an apparent build-up in population during 1950. In Saskatchewan, infestations of the pale

western cutworm were again widespread and caused more severe damage than in 1950, when damage was more serious than for many years. The most severe damage occurred in west-central Saskatchewan in the Mildren, Rosetown, Herschel, Stranraer, Kindersley, Wartime, Beechy, and Demaine districts. Thousands of acres of crop were destroyed in this area, the loss ranging from patchiness and thinning to complete destruction of the crop on half-section fields. Many re-seeded crops were also destroyed. Damage was caused chiefly to wheat, although some losses occurred in oats, barley, and flax. Localized infestations resulting in crop losses up to 50 per cent or more occurred in the Hazlet district of southwestern Saskatchewan; the Dundurn, Hanley, and Kenaston districts in central Saskatchewan; and the Yorkton, Wroxtton, and Kamsack districts in eastern Saskatchewan, this area experiencing its first serious outbreak of this cutworm. A marked reduction in the infestation throughout the Province in 1952 is predicted because of weather conditions unfavourable to moth activity, including oviposition. The red-backed cutworm inflicted damage ranging from slight thinning to about 50 per cent loss in several wheat fields in the Saskatoon-Floral-Clavet area, and many gardens were completely destroyed. Slight damage occurred in northeastern Saskatchewan and about Swift Current in the southwestern area. *Euxoa detersea* (Wlk.) occurred along with the red-backed cutworm on wheat and spring rye, predominating in the more sandy areas, in the Saskatoon-Floral-Clavet infestation. The army cutworm infested a few fields at Robsart and Vidora in southwestern Saskatchewan but did little damage. Climbing cutworms, in general, were of little importance, although light infestations of the flax bollworm were observed at Rosetown and Kindersley in west-central Saskatchewan. The wheat head armyworm occurred in very small numbers in west-central and southeastern Saskatchewan. The bertha armyworm was not reported. Cutworms apparently caused little injury to field crops in Manitoba, but the red-backed cutworm was troublesome in gardens at Brandon; and at Winnipeg, where it was more abundant than for several years. The bertha armyworm and the army cutworm were scarce and the armyworm was not reported.

Reports from Prince Edward, Hastings, and Carleton counties in eastern Ontario indicated that cutworms of various species were abundant and very injurious to transplants and seedlings. The armyworm did not occur in outbreak form in Ontario. In Quebec, moderate to severe cutworm infestations occurred on various crops, including tobacco at St. Jean, and gladioli, tomatoes, and crucifers at St. Anne de la Pocatiere. Cutworms were abundant in the Fredericton area of New Brunswick, causing much replanting of crops. The dark-sided cutworm and *Euxoa declarata decolor* (Morr.) damaged 8 to 10 per cent of the fruit in a strawberry plantation mulched with sawdust; other plots were less severely damaged. The fall armyworm damaged corn in the Lakeville-Douglas Harbour area. For the second consecutive year cutworms were unusually numerous in Nova Scotia and many garden crops suffered severe damage. During May, the black and the spotted cutworms were moderately abundant in Kings County. In June, *Euxoa* spp. constituted about 90 per cent and *Feltia* spp. about 10 per cent of all cutworms collected. The fall armyworm was abundant and injurious to corn. The variegated cutworm was occasionally reported, and the armyworm was scarce for the second consecutive year. The variegated cutworm caused considerable damage throughout Prince Edward Island, particularly in gardens. The red-backed cutworm was scarce in comparison with the past two years, causing only slight damage in grain fields in the eastern part of the Province; the fall armyworm was not as numerous on corn as in 1950. Cutworms were reported to be abundant in gardens in Newfoundland.

EUROPEAN EARWIG. — In British Columbia the earwig was troublesome in the lower Fraser Valley and on Vancouver Island but was almost absent in the Agassiz district. It was present in considerable numbers, and apparently increasing, throughout the Okanagan Valley, and occurred in at least one Kamloops garden. The infestation in St. John's Nfld., continued to increase in intensity, and spread from St. John's East to older parts of the city. Cotton goods were damaged in a residence at Westmount, Que., and a single specimen was found in an Ottawa, Ont., home.

GRASSHOPPERS. — There was a marked increase in grasshopper populations throughout the southern interior of British Columbia and on Vancouver Island, and damage was aggravated by a long, dry summer. *Cannula pellucida* (Scudd.) and *Melanoplus mexicanus mexicanus*



(Sauss.) increased in the Roosville and St. Mary's Prairie areas of the East Kootenays, in the Lac du Bois district near Kamloops, along the Fraser River west of Pavilion, and in the southern Cariboo and the Chilcotin. Local outbreaks were reported also from near Kettle Valley, Westbank, Princeton, Aspen Grove, Merritt, Raleigh, and Monte Creek. *Melanoplus femur-rubrum* (Deg.) was the major species in a severe outbreak in the lower Fraser Valley, and in a light outbreak in the southern Okanagan, causing much damage to grain, truck crops, and fruit. On Vancouver Island *C. pellucida* predominated in the Saanich area and *Melanoplus bivittatus* (Say) in the Duncan area. The outbreaks of 1950 in the northern Cariboo, central British Columbia, and the Peace River area completely subsided.

The hatching of grasshoppers was very uneven in Alberta, and, as in 1950, later than usual. Development throughout the season also was very uneven but population levels remained constant. Between Lethbridge and Calgary there was a larger proportion of *M. m. mexicanus* and a smaller proportion of *C. pellucida* than in recent years. Elsewhere species distribution was little changed, *C. pellucida* being predominant in the Watts-Craigmyle area, a mixture of *C. pellucida*, *M. m. mexicanus*, *Melanoplus packardii* Scudd., and *M. bivittatus* east of that area, and mostly *M. bivittatus* and *C. pellucida* west to Calgary. *M. bivittatus* was prevalent south of Lethbridge and eastward, gradually being replaced by *M. m. mexicanus* toward Medicine Hat. Late development and adverse weather conditions reduced oviposition and the forecast for 1952 indicates only small pockets of light infestation.

After three successive years of widespread and severe grasshopper outbreaks in Saskatchewan, 1951 saw a marked diminution in both numbers and severity of damage. For 1951 a comparatively reduced area of infestation of about 40,000 square miles had been forecast. No "very severe" areas were included, and the "severe" areas were relatively small, so that the actual threat in the infested area was estimated to be only about half that of 1950. As the outbreak developed, it was well below even these expectations. In the "severe" and some other forecast areas, a few farmers did have heavy grasshopper populations requiring control, but this was by no means general within these areas. Excellent conditions for the growth of cereal crops brought about some recovery in the small acreage that had been damaged, and minimized further damage; this, together with the control campaign, left the net destruction caused by grasshoppers small indeed. Local areas of outbreak included Sceptre and Webb, where *C. pellucida* occurred, and an area between Hanley and Dundurn, where *M. m. mexicanus* was present. Control measures were carried out also in the Abbey-Sceptre-Leader district and the Francis-Odesa-Lajord area. The fungus disease *Empusa grylli* Fres. was a major control factor, particularly in west-central Saskatchewan, where it had been conspicuous in 1950. Fall surveys indicated that eggs of the lesser migratory and the clear-winged grasshoppers were very scarce. Only the two-striped grasshopper developed early enough to deposit a light infestation of eggs on the Regina Plains, a comparatively small area. The forecast for 1952, therefore, is for the lightest outbreak in the Province in 20 years.

In Manitoba, too, grasshopper eggs hatched late and irregularly, so that the outbreak was not as severe as forecast. The two-striped grasshopper was most abundant, the clear-winged grasshopper second in importance, and the lesser migratory grasshopper of minor importance. Franklin gulls were important predators. Fall surveys indicated a general reduction in populations and a retraction of the infested area to the central Red River Valley in 1952.

In Eastern Canada, grasshoppers were of minor importance as pests in 1951. In early summer *M. femur-rubrum* and *C. pellucida* were moderately numerous in Hastings County, Ont., and the St. Maurice Valley, Que., but populations diminished as the season progressed. *M. m. mexicanus* also was reported in Hastings County and *M. bivittatus* in the St. Maurice Valley. Some minor damage was caused to clover in the vicinity of Forest, Ont. Grasshoppers were scarce in the Maritime area and no damage was reported.

**JAPANESE BEETLE.** — Trapping in southern regions of Eastern Canada resulted in the capture of 184 beetles in 1951 as compared with 178 and 224 in 1949 and 1950 respectively. One beetle was taken at Halifax, N.S., and the following captures were made in Ontario: Toronto, 6; Hamilton, 48; Niagara Falls, 7; Fort Erie, 29; Port Burwell, 18; St. Thomas, 2; Windsor, 73.

**JUNE BEETLES.** — White grubs, believed to be *Phyllophaga anxia* (Lec.), were reported to have damaged perennials in a Kamloops, B.C., flower garden. Similar damage was reported from Vernon, and strawberries were attacked at Enderby. *Polyphylla perversa* Csy. severely damaged strawberry plantings in the Keating district of Vancouver Island. In Alberta, only one report of damage by larvae of *P. anxia* was received, although reports were numerous in 1950. By contrast, reports of injury by this species increased in Saskatchewan in 1951. Single reports were received from Meadow Lake, Moose Range, and Weirdale in northern Saskatchewan; three reports were received from Theodore and one from Leross in the east-central area; a heavy infestation occurred at Harris in the west-central area; and in the southwest, alfalfa was damaged at Garden Head.

In Ontario, *P. anxia* and *Phyllophaga fusca* (Froel.) were rated among the most destructive insect pests of the year. Much pasture land was severely damaged; lawns and golf courses were ruined; and potatoes, turnips, wheat, spring grain, strawberries, and garden crops were damaged. Eastern Ontario westward to the Guelph area was most seriously affected, severe damage occurring in Lanark, Renfrew, Frontenac, Addington, Hastings, Peterborough, Ontario, Haliburton, and Wellington counties. Light to moderate damage occurred in Glengarry, Carleton, Leeds, Durham, Muskoka, and Peel counties. A major flight of June beetles is predicted for the Niagara Peninsula and other Brood C areas in 1952. In Quebec, light damage was caused in the Montreal area, and moderate injury occurred on potatoes and strawberries near Ste. Anne de la Pocatiere. In New Brunswick some damage was noted at Fredericton, and injury to strawberries was common at Washademoak. *Phyllophaga* spp. occurred in small numbers in central Newfoundland, particularly about Grand Falls.

**RED TURNIP BEETLE.** — A much larger population than usual damaged cruciferous garden crops in northern Alberta but elsewhere in the Province and in Saskatchewan infestations were restricted mainly to weeds. Occurrences were reported from Watson, Saskatoon, and North Battleford in Saskatchewan.

**TARNISHED PLANT BUG.** — Populations were small in Manitoba but generally large throughout most of Eastern Canada, where flowering plants, notably dahlias, were damaged, and potatoes were attacked in some areas.

**WIREWORMS.** — Good growing conditions held damage to a minimum in northern Alberta, but in southern areas, notably at Chin, Taber, Redlaw, and Irvine, some crop thinning ranging up to 50 per cent occurred where deep seeding was practised. Damage to grain crops was not as serious as in 1950 in Saskatchewan, but the prairie grain wireworm was again responsible for widespread thinning of cereal crops and severe damage to vegetables, especially potatoes, throughout the agricultural area of central and western Saskatchewan. *Hypolithus nocturnus* Esch. was mainly responsible for light to moderate damage and occasional serious losses in cereal crops throughout northeastern Saskatchewan. As usual, damage was most severe in wheat seeded on summer-fallow in medium-textured soils, but grain seeded on stubble was seriously damaged in some instances. Although light thinning occurred throughout the area subject to wireworm damage, severe thinning of crops was relatively rare and little re-seeding was necessary. Limited surveys indicated general light thinning of crops in the southwestern, south-central, east-central, north-central, and northeastern parts of Saskatchewan. Moderate thinning occurred in the central, west-central, and southeastern parts and in the Scott area of the northwestern part of the Province. However, moderate to severe damage, chiefly to wheat, was general in the Kerrobert area, where rainfall was abnormally low after planting; and in a small number of fields in the Hanley, Outlook, Conquest, Herbert, Swift Current, Stewart Valley, Scott, Unity, St. Louis, Tisdale, Porcupine Plains, and Smoky Burn districts. Considerable damage to strawberry fruit by beetles of *Aeolus mellillus* (Say) was reported at Dodsland. In Manitoba, the prairie grain wireworm caused relatively little damage. The destruction of a 60-acre field of wheat near Douglas by *Hypolithus nocturnus* Esch. constituted the first record of this species in such numbers.



Wireworm damage in Ontario was reported to be somewhat greater than usual. *Limonijs agonus* (Say), the principal species in Kent County, along with species of *Aeolus*, *Agriotes*, *Melanotus*, and *Ctenicera*, caused from 1 to 10 per cent damage to spring grain, corn, tobacco, tomato, potato, cabbage, and sugar beet. In Dufferin County, 5 per cent damage was caused to spring grain at Alliston and 3 acres of potatoes were destroyed at Shelburne. Corn was damaged by *Aeolus mellillus* at Jeanettes Creek, Essex Co., and Forest, Lambton Co. Wireworms were of minor importance in Bruce, Grey, Huron, and Perth counties, although *Agriotes* sp. damaged a small field of turnips in Bruce and a few fields of spring grain in Perth. Tobacco was attacked lightly in Elgin County. Populations were about normal in Nova Scotia, where the wheat wireworm was the most numerous and injurious species in potato fields. *Hypolithus abbreviatus* (Say), *Ctenicera cylindriciformis* (Hbst.) and *Dalopius* sp., prob. *pallidus* Brown, were found in small numbers. *Oestodes tenuicollis* (Rand.) occurred in low-lying, sandy land near Canning. For the first time in Nova Scotia, *Agriotes lineatus* (L.) was taken at Chebogue Point, and *Agriotes sputator* (L.) at Marshalls Town. Wireworms caused considerable damage to root and potato crops in the Avalon Peninsula, Nfld.

#### FIELD CROP INSECTS

**APHIDS.** — A few moderate infestations of the English grain aphid were noted in British Columbia but it was much less prevalent than in 1949 and 1950. Aphids, believed to be the greenbug, caused some damage to barley and wheat at Armstrong. Severe infestations of the English grain aphid occurred at Del Bonita, Claresholm, Vulcan, and Nobleford in Alberta but little damage resulted. This species was prevalent also in Saskatchewan but in lighter, less widespread infestations than in 1950. Occurrences on wheat, oats, and barley were reported from Nipawin, Carrot River, Birch Hills, Spruce Lake, Leask, Maidstone, and Saskatoon; and it was generally present on cereal grains and flax throughout central, west-central, and northeastern Saskatchewan. Severe infestations and some serious damage to fall-seeded rye and winter wheat were reported from the Clairmont district in the Peace River area. The greenbug, after three successive years of outbreak, was of little importance in 1951. Light infestations were reported from Maidstone in northwestern and the Carrot River-Pas Trail area in northeastern Saskatchewan. For the first time in the Province, a root-infesting aphid, *Forda* sp., on wheat, was reported from Davidson. Grain aphids did not occur in economic numbers in Manitoba. In Ontario, specimens of the greenbug taken in traps at Erie Beach constituted the first record in the area. The corn leaf aphid was of minor importance in southwestern Ontario, New Brunswick, and Nova Scotia.

**ARCTIDS.** — A local outbreak of *Apantesis blakei* Grt. in the Turin-Retlaw area of Alberta destroyed 35 acres of fall rye and damaged 50 acres of spring-sown wheat. In southwestern Saskatchewan, rye was infested in the Maple Creek district, and both rye and range lands were affected from Portreeve west to the Alberta border but damage was negligible. *Diacrisia* sp. occurred in small numbers in northern Saskatchewan, and *Colias* spp. were scarce on alfalfa in Manitoba.

**BARLEY JOINTWORM.** — Up to 100 per cent infestation of barley in northeastern and central areas of Prince Edward Island caused considerable decrease in the crop yield.

**BURROWER BUGS.** — *Sehirus cinctus* (P. de B.) is believed to have been the cause of complete destruction of the alsike clover seed crop in 1949, and of serious damage in 1951, northeast of Prince George in the Salmon River area of British Columbia.

**CLOVER WEEVILS.** — The sweetclover weevil is now generally distributed throughout the clover-growing areas of Alberta but damage was not severe in 1951. Large populations were reported generally in Saskatchewan and Manitoba but larval mortality and favourable growing conditions held damage to a minimum. In Ontario, damage was the lightest in several years. *Sitona tibialis* (Hbst.) was reported to have seriously damaged seedling alfalfa at Baytree and Gordondale in the Peace River district in Alberta, and although present on alfalfa in northeastern Saskatchewan was not considered to have caused appreciable injury. *Tychius picirostris*



(Fab.) was observed on alsike and white clovers from Vancouver north to Soda Creek and east to Grand Forks in British Columbia. In southwestern Ontario it caused severe injury to alsike seed crops. Sub-economic occurrences of other clover weevils in the Ottawa and Carp areas of Ontario included *Hypera nigrirostris* (F.) and *Hypera meleus* (F.) on red, alsike, and ladino clovers; *Sitona hispidula* (F.) on ladino and red clovers; and *Tychius stephensi* Schönh. on red clover.

**CLOVER SEED MIDGE.** — This midge greatly reduced the seed crop in most fields of red clover in the Carp, Kinburn, Antrim, and Pakenham areas of Ontario.

**CORN EARWORM.** — Saskatoon was the only point in the Prairie Provinces from which the corn earworm was reported in 1951. It was very scarce also in Ontario and Quebec, but in New Brunswick some severe late-season damage was caused to corn in Charlotte, York, Sunbury, Queens, Kings, St. John, Albert, and Westmorland counties; light to medium outbreaks occurred in Carleton, Restigouche, Northumberland, and Kent counties. Variable late-season damage occurred in Nova Scotia, moderate damage in Prince Edward Island, and some severe damage to garden corn in the Avalon Peninsula in Newfoundland.

**CORN BORERS.** — A survey of the southwestern area of Saskatchewan revealed infestations of the European corn borer in Estevan, Carnduff, Carievale, and Roche Percee, and in local areas near Shands, Estevan, Whitewood, Moosomin, and Manor, the last three being new records. In Manitoba, infestation was spotty and less severe than in 1950; an average of 5 to 10 per cent of the ears, mainly of sweet corn, were damaged. One field at Altona had 30 per cent ear infestation. Infestation of canning corn was the lightest in several years in central Ontario, and, in a few fields of corn and peppers, light also in southwestern areas, there being few second-generation larvae; populations were larger in eastern Ontario, where damage was general. In Quebec, severe infestations were reported only from the Montreal and St. Jean areas, ear damage in canning corn averaging 15 to 20 per cent, and, in sweet corn, up to 35 per cent, in the latter area. Infestation was generally more severe than in 1950 in New Brunswick, and high also in Nova Scotia, where ear infestation ranged as high as 50 per cent in some fields. A western corn borer, *Helotropha reniformis* Grt., occurred for the first time since 1919 on corn at Winnipeg, Gunton, St. Rose, Dauphin, Shoal Lake, and Middlechurch in Manitoba.

**HESSIAN FLY.** — The hessian fly was not reported from Western Canada, but it occurred in outbreak form in central Ontario, where estimates of crop infestation ran as high as 70 to 80 per cent in Norfolk, Haldimand, Lincoln, Brant, Middlesex, Huron, Halton, Peel, York, Hastings, Prince Edward, Ontario, and Simcoe counties. Field damage frequently ranged up to 50 per cent. Infestation in Kent County was less severe than in 1950.

**LEGUME-POLLINATING INSECTS.** — A leaf-cutter bee, *Megachile* (*Xanthosarus*) *denticarsus* Sladen, was unusually abundant on alfalfa at Scandia, Rolling Hills, Medicine Hat, and Irvine, in Alberta. In Saskatchewan, cool, rainy weather throughout the summer seriously limited the pollinating activity of bees and, combined with similar weather throughout the spring and fall months, was probably the chief factor in limiting the development of bumble bee populations to very small numbers in 1951. *Bombus terricola* Kby. and *Bombus ternarius* Say were the chief bumble bee pollinators of alfalfa. *Bombus borealis* Kby. was fairly numerous in some red clover fields in the White Fox and Cherry Ridge districts. Other *Bombus* species and species of *Psithyrus* and *Megachile* visited alfalfa and other legumes in small numbers. In Manitoba, *B. terricola* and other bumble bees occurred in much larger numbers than usual, almost replacing *Megachile* spp. as pollinators of alfalfa. *Bombus* spp. were also reported to be numerous in eastern Ontario.

**OAT NEMATODE.** — *Heterodera avenae* Lind, Rostrup, & Ravn, which has an interrupted range between Waterloo and Peterborough in central Ontario, caused injury somewhat below the average but continued to spread slowly.

**PLANT BUGS.** — *Lygus oblineatus* (Say) was present in large populations on irrigated alfalfa throughout southern Alberta and in the Peace River area causing up to 25 per cent destruction of bloom. *Lygus* spp. were again the most common of the insects injurious to alfalfa in northern Saskatchewan, populations ranging up to 50 per cent higher than in 1950. Populations of *L. oblineatus* were low on alfalfa in Manitoba, and generally low in clovers in Ontario. Moderate injury to hay crops was reported from Newfoundland. Medium populations of *Adelphocoris rapidus* (Say) occurred on alfalfa in the Peace River district, and small populations were reported in Saskatchewan, where it was more numerous than usual, and in Manitoba. Severe infestations of *Adelphocoris superbus* (Uhl.) occurred on alfalfa in the Scandia district of Alberta. The species was not observed on alfalfa in northern Saskatchewan but was collected on *Monarda* sp. in central and southern areas. *Plagiognathus obscurus* Uhl. caused severe damage in many alfalfa fields throughout northern Saskatchewan. Small numbers of *Adelphocoris lineolatus* (Goeze) were observed on alfalfa in northeastern Saskatchewan and in Manitoba. *Lopidea* sp., prob. *dakota* Knight, was observed in large numbers in the same alfalfa field near White Fox, Sask., in which it was observed in 1950; moderate numbers were observed also in a field near Simmie in the southwest. *Chlamydatus* sp., never known to cause damage, was again observed in small numbers in northern areas of the Province. *Miris dolabratus* (L.) was abundant on timothy in the Ottawa area of Ontario and was observed feeding on the heads.

**SAY STINK BUG.** — Numbers were generally reduced in southern Alberta, light infestations occurring at Turin, Taber, and Macleod. An occurrence on wheat at Dunblane was the only record in Saskatchewan.

**SPITTLEBUGS.** — The meadow spittlebug was abundant on forage crops throughout Ontario and is believed to have been the cause of some loss.

**SUNFLOWER INSECTS.** — The sunflower beetle caused minor damage at Pike Lake and Saskatoon in Saskatchewan, and at Altona in Manitoba, where it, as well as the sunflower moth, increased somewhat. In Manitoba, *Phalonia hospes* Wlshn. was very abundant and more widespread than in 1950, although a local reduction, believed due to parasitism, occurred at Altona. A moderate larval population of *Eucosma* sp., prob. *pulveratana* Wlshn., occurred at Gnadenthal. The ragweed plant bug was present on sunflowers in large numbers, as usual. A weevil, *Desmoris constrictus* (Say), was abundant at Treesbank. The sunflower maggot has increased for three years, causing considerable damage and an average infestation of 96 per cent in 1951. *Euaestoides finalis* (Loew) occurred in small numbers and caused little damage.

**TOBACCO INSECTS.** — In the tobacco-growing areas of southwestern Ontario, the green peach aphid occurred generally along the north shore of Lake Erie and was abundant at Blenheim, Leamington, and Port Stanley; populations were low in the Simcoe, Delhi, and Mount Brydges areas. Cutworms caused from 10 to 90 per cent damage to tobacco seedlings in light to medium soil areas. The tomato hornworm, although nowhere severe, was slightly more injurious to tobacco and tomato than in 1950 in Ontario, and caused some damage to tobacco in Quebec. The potato flea beetle caused very little damage, and the tobacco budworm apparently caused none. *Crambus* sp. destroyed about 90 per cent of tobacco transplants, following timothy, in a 3-acre field near Harrow, Ont.

**WHEAT STEM SAWFLY.** — In Alberta, infestation generally was slightly reduced from that of 1950, and good crop conditions reduced losses to insignificance. Severe infestations occurred in a few fields at Nobleford, Carmangay, and Warner; moderate infestations at Vulcan, Champion, Lomond, Enchant, Stirling, and Milk River; and light infestations elsewhere in the brown soil areas. In Saskatchewan, too, infestations were slightly reduced, with little change in distribution. They were very severe in the Moose Jaw, Regina, Stoughton, Ogema, Assiniboia, and intermediate districts of south-central and southeastern Saskatchewan, and in the Kenaston-Broderick and Mildred-Brock districts in central and west-central areas respectively. Severe infestations linked these districts, extended to Kerrobert, surrounded the very severely infested area in the southeast, and occurred between Shaunavon and Kincaid in the midst of an area of



lighter infestation in southwestern Saskatchewan. Infestation was light in the extreme southwest corner of the Province and moderate elsewhere in the general area of infestation. Infestations of the European wheat stem sawfly were reduced, as compared with 1950, throughout southern Ontario.

#### VEGETABLE INSECTS

**APHIDS.** — The cabbage aphid was present in outbreak numbers on the southwestern mainland of British Columbia and caused severe injury to cabbage, turnip, and Brussels sprouts. Infestations on Vancouver Island were moderate on stem brassicas but severe on turnips. In Alberta, the sugar-beet root aphid overwintered in the soil of infested fields for the second consecutive year; no serious infestations were reported. Local populations of aphids occurred on lettuce at Lethbridge. Aphids were reported generally throughout north-central Saskatchewan. Lettuce was damaged at Hubbard, and at Saskatoon aphids were abundant on potato, and a root aphid, *Triphidaphis phaseoli* (Passerini), occurred on bean, neither causing any appreciable damage. At Assiniboia, aphids occurred on sprouting potatoes in storage. Populations were small on potato at Winkler and other points in Manitoba. In Ontario the cabbage aphid generally caused only light damage. Reports from Kent County and from the Ottawa and Bradford areas indicated an abundance of the pea aphid on several varieties of clover but damage was light. Infestation was considerable on peas in Essex County and other southwestern areas. The melon aphid occurred in two gardens near Chatham. A few fields of beets in Kent County were infested with the sugar-beet root aphid. *Macrosiphum erigeronensis* (Thomas) occurred on head lettuce in the Erieau Marsh area, and an unidentified species on lettuce in the Holland Marsh area. The aphid species that commonly attack potatoes were less numerous than usual in Quebec; populations remained abnormally small throughout the season in New Brunswick, Nova Scotia, and Newfoundland; they were small also in Prince Edward Island early in the season, but built up rapidly in August and declined to zero in September, causing injury in only a few fields. The pea aphid infested canning peas earlier than usual at Middleton, N.S., and was reported scarce in Prince Edward Island. The cabbage aphid caused only slight damage in Newfoundland.

**ASPARAGUS BEETLES.** — *Crioceris* spp. were not reported as injurious anywhere in Canada.

**CABBAGEWORMS.** — The imported cabbageworm was less abundant than usual on the lower mainland of British Columbia, but postmigration control measures were necessary in this area as well as in Alberta. Populations were almost absent in Saskatchewan. Overwintering conditions were good in Manitoba but early adults disappeared quickly and populations remained low until August. Damage to cabbage and cauliflower was severe and greater than usual throughout Ontario and Quebec. No severe damage occurred until August in New Brunswick, and in general the pest was not serious throughout the Maritime area. The cabbage looper, for the second successive year, caused no damage in Manitoba, and throughout Eastern Canada it was not economically important. The diamondback moth occurred in small numbers from Manitoba eastward, slight damage being reported only in Newfoundland. Populations of the zebra caterpillar were small in Ontario and Quebec. *Evergestis straminealis* (Hbn.) continued to decline in numbers in Newfoundland.

**CARROT RUST FLY.** — Late carrots suffered considerable damage in the lower Fraser Valley, B.C., and averaged about 25 per cent in the Armstrong district. Minor damage occurred in the Nelson district, and injury, typical of this insect, appeared at Kamloops. Damage was generally severe throughout Eastern Canada. It was greater than usual at Bradford, Ont., and injury to celery was reported from the Burlington area. In New Brunswick severe damage to carrots was reported from York, St. John, and Sunbury counties, and, in addition, celery was extensively damaged in St. John, and parsnips in Sunbury. The insect appeared in considerable numbers for the first time in the Mauderville area. Notable abundance was reported at Berwick, N.S., and outbreak numbers for the first time in several years at Centreville. Although numerous in both Prince Edward Island and Newfoundland, a minor increase in the former and a decrease in the latter was reported.



**COLORADO POTATO BEETLE.** — In British Columbia, infestation in the East Kootenay area was light, and in the West Kootenay area heaviest infestations occurred at Shoreacres, Glade, and China Creek. A survey in the southern Okanagan revealed only two small infestations, both at Osoyoos. Infestation in northern Alberta appeared to have at last receded southward to a more normal geographical area, about 100 miles south of Edmonton. No damage was reported in southern Alberta or in Saskatchewan, and only one occurrence from each, Roxburn and Pike Lake respectively. In Manitoba, damage was light at Brandon, and populations were somewhat increased over those of 1950 at Winnipeg. Populations remained low throughout Eastern Canada, the few exceptions resulting from inadequate control measures. The insect was conspicuous by its absence in the Lincoln area of New Brunswick and scarce at Maugerville, and was apparently not present on Cape Sable Island, N. S.

**CUCUMBER BEETLES.** — Both the striped and the spotted cucumber beetles were present in Ontario in numbers sufficient to cause some damage to the fruit of squash in Essex and Kent counties, and of pumpkin in Prince Edward County. Populations were low in the Ottawa and Bradford areas of Ontario and in Quebec, and normal in Nova Scotia.

**FLEA BEETLES.** — The potato flea beetle was not reported in Saskatchewan. In Manitoba, it was scarce at Winkler and Winnipeg, and in normal abundance at Brandon. Normal populations caused some injury to potatoes and to tomato transplants in Ontario and Quebec. Second-generation populations were small in the Maritime area. In British Columbia, the western potato flea beetle was present in large numbers on potatoes in the Cariboo area. The tuber flea beetle occurred on practically all untreated potatoes in the Kamloops, Okanagan, and Similkameen districts, was present in average numbers on the lower mainland, and was in reduced abundance on Vancouver Island. Tomatoes as well as potatoes were damaged at Kamloops. *Phyllotreta albionica* (Lec.) was scarce on the lower mainland but present in normal numbers on Vancouver Island, and minor damage was reported from Newfoundland. The striped flea beetle occurred in normal abundance in Manitoba, in light infestations on garden crucifers in southwestern Ontario, and at Maugerville, N.B. *Phyllotreta striolata* (F.) was reported to be normally abundant in Manitoba, in heavy infestations on turnips at St. Jean, Que., and in small numbers on turnips and cabbage seedlings in Newfoundland. *Phyllotreta* spp. caused severe damage to beet seedlings at Raymond, Alta.; and turnip seedlings were severely damaged at Totnes and lightly damaged at Saskatoon in Saskatchewan. The hop flea beetle was more abundant than in recent years in hop yards in southwestern British Columbia, normally abundant in Manitoba, and numerous on rhubarb in Nova Scotia.

**LACEBUGS.** — Severe damage to beans at Cranbrook, B.C., was reported to have been caused by *Corythucha distincta* O. & D.

**LAMELLICORN BEETLES.** — For the second successive year, potatoes in the vicinity of Elm Creek, Man., were damaged, apparently by *Onthophagus hecate* (Panz.).

**LEAFHOPPERS.** — The potato leafhopper was unreported in Saskatchewan and scarce at Brandon, Winnipeg, and Winkler in Manitoba. It was common but not economically important in Ontario and Quebec. A heavy infestation occurred at Lincoln, N.B., but elsewhere in the Maritime area damage was negligible. The status of the six-spotted leafhopper compared with that of the potato leafhopper in Saskatchewan and Manitoba. In Ontario, slight damage was caused to head lettuce in the Erieau Marsh area, and carrot foliage was damaged at Ottawa and Bradford.

**MEXICAN BEAN BEETLE.** — This insect caused considerable damage in the Fonthill and Grimsby areas of the Niagara Peninsula, Ont., continued to decrease in numbers in the Chateauguay-Huntingdon district of Quebec, and was reported from Fredericton, N.B.

**NEMATODES.** — Infestations of the sugar-beet nematode, *Heterodera schachtii* Schmidt, 1871, continued to increase in intensity but failed to spread in the Blackwell area of Ontario; it attacked a wide variety of garden plants. The potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, did not cause any appreciable crop injury in Prince Edward Island, probably

mainly because potatoes were not grown on infested land. Other nematodes found in potatoes in Prince Edward Island included *Aphelenchus avenae* Bastian, 1865, at York, and *Aphelenchoides parietinus* (Bastian, 1865) Steiner, 1932, at Miscouche.

**MAGGOTS IN ONION.** — Damage by the onion maggot was severe on untreated crops throughout British Columbia and moderate to severe throughout the Prairie Provinces. A general reduction in numbers was noted in southwestern Ontario, and an increase was reported at Ottawa and Bradford in the east. Populations were generally large in Quebec, although varying greatly from field to field. Damage was light at Manguerville, N.B., and moderate in Nova Scotia, but increased in Prince Edward Island, where destruction ranged from 50 to 75 per cent. Larval populations of the lesser bulb fly in onions equalled those of the onion maggot at Vernon in August, but it attacks only damaged plants and its economic status is not known.

**PEA MOTH.** — Populations remained at a low ebb in southwestern British Columbia, although infestations of up to 5 per cent indicated a slight increase. Reports from Nova Scotia and Prince Edward Island indicated a decrease in population and little severe damage.

**PEPPERGRASS BEETLE.** — For the first time in several years in Saskatchewan, this insect severely damaged turnips in the northwestern part of the Province.

**POTATO STEM BORER.** — Corn and potatoes were severely damaged at Kinsman's Corner, Kings Co., N.S.; considerable damage occurred in gardens at Fredericton, N.B.; and slight damage was reported from Newfoundland.

**A RADISH WEEVIL.** — Radishes at Jordan Station in the Niagara Peninsula, Ont., were severely damaged by *Ceutorhynchus erysimi* (F.), a new pest.

**ROOT MAGGOTS AFFECTING CRUCIFERAE.** — Root maggots, chiefly the cabbage maggot, were normally abundant in British Columbia, severe infestations in turnips being reported from the Alberni district on Vancouver Island, and from the Salmon River Valley and the Salmon Arm and Kamloops districts on the mainland. This species, along with *Hylemya crucifera* Huck., was present on turnips at Picture Butte, Vauxhall, Taber, and Coaldale in Alberta. The latter species damaged turnips, and infested up to 20 per cent of cauliflower at Saskatoon, Sask. In Manitoba, cauliflower and turnip were heavily infested at Brandon, but at Dauphin infestation was lighter than in 1950. *Hylemya planipalpus* (Stein.) caused slight damage to radish at Saskatoon, Sask. In Ontario, root maggots, chiefly the cabbage maggot severely damaged cabbage, cauliflower, and early-sown turnips throughout the Province early in the season. Damage was particularly severe north of Hamilton, and assumed outbreak proportions in the Ottawa area. Severe infestations were reported generally in Quebec. Early cabbage and cauliflower were severely damaged in the Manguerville and Sheffield areas of New Brunswick, only 10 to 20 per cent of the cauliflower crop being marketable; radish and turnip also were attacked. The infestation was checked, however, by unfavourable weather conditions, and only light to medium damage was done to late crops. Root maggots continued to be a prime pest in Nova Scotia, many small fields of cabbage and turnips being completely infested. There was considerable variation in the degree of infestation in Prince Edward Island, and although injury was less severe than in 1949 and 1950, it was extensive, particularly on early crucifers. Root maggots, particularly the cabbage maggot, were prevalent but not as abundant as in 1950 in Newfoundland; heaviest infestations occurred in eastern areas. *Hylemya trichodactyla* (Rond.) occurred on turnip, cabbage, and cauliflower in New Brunswick, and was reported from Newfoundland.

**SEED-CORN MAGGOT.** — Turnip, onion, and radish were attacked by this pest in Manitoba but populations generally were small. Many fields of white, lima, and red kidney beans in Kent County, Ont., had to be re-seeded, and an unusual occurrence on soybeans in Essex County was reported, but, in general, infestation was less severe than usual in the Province. Injury was general in the vicinity of St. Jean, Que., and at St. Michel several acres of beans and cucumbers had to be re-seeded. Populations in many areas of Quebec were larger than in 1950. Normal abundance on beans, corn, and cucumbers was reported from Nova Scotia, and reduced

infestations occurred in Prince Edward Island, where a few fields of potatoes had to be replanted, and moderate damage was caused to cucumber and bean. Extensive damage to turnip was reported from Newfoundland.

**SLUGS.** — Little damage occurred in southwestern areas of British Columbia but slugs were unusually injurious in gardens at Kamloops, possibly a result of increased irrigation. Reports of damage continued to increase in the Winnipeg, Man., area, and throughout Eastern Canada slugs were very numerous and injurious to garden and field crops, showing little food preference.

**SPINACH LEAF MINER.** — Fifty per cent damage occurred on a 50-acre plot of spinach in Manitoba, and small numbers infested sugar beets. The latter as well as garden beets were infested in southwestern Ontario but damage was slight. A light, local infestation occurred on spinach in Essex County, Ont.

**SQUASH BUG.** — Small populations caused only minor damage throughout Ontario.

**SQUASH VINE BORER.** — Infestation of golden and green hubbard squash was general and damage severe in southwestern Ontario.

**THRIPS.** — Onion crops in the Kamloops area and the Okanagan Valley, B.C., were seriously threatened by the onion thrips until control measures were applied. Infestation in the onion-growing area of Erieau Marsh, Ont., was earlier and more severe than in recent years, and contributed to considerable crop loss; the thrips attacked head lettuce, after the onion harvest. A species of thrips was more common than usual on cucumber at Winnipeg, Man.

**TOMATO HORNWORM.** — Infestation in Ontario and Quebec was much lighter than usual and damage to tomatoes was negligible. The insect was not reported in Nova Scotia.

#### FRUIT INSECTS

**APHIDS.** — Populations of aphids on apple were at comparatively low levels throughout Canada in 1951. *Aphis pomi* Deg., though requiring control in some areas, was less prevalent than in 1950 in British Columbia. Local outbreaks occurred in Norfolk County and at Morrisburg in Ontario. Considerable populations built up in the St. Jean area of Quebec but infestation generally was not serious. Moderate populations developed in New Brunswick and Nova Scotia but were reduced by predators. *Anuraphis roseus* Baker was less numerous than in 1950, and of little importance in Ontario and Quebec. In Nova Scotia populations remained low and injury to apples was slight. Numbers of *Eriosoma lanigerum* (Hausm.) were small and comparable to those of 1950 in British Columbia and Nova Scotia, while in Ontario a slight increase occurred and some large populations were reported in the Niagara Peninsula. *Rhopalosiphum prunifoliae* (Fitch) occurred in average numbers in Nova Scotia. The black cherry aphid caused little damage in British Columbia, where control measures were generally effective. In Ontario, light infestations occurred in the Niagara district and scattered damage was reported in eastern areas. The currant aphid was generally abundant in Manitoba, but in Prince Edward Island only light infestations were reported. The mealy plum aphid occurred in small numbers in most British Columbia orchards, being less prevalent than in recent years. Plum trees were severely infested at Brandon and Morden in Manitoba. Little damage occurred in the Niagara Peninsula, Ont., but in Essex County populations were larger than in 1950 and severe infestations common.

**APPLE AND THORN SKELETONIZER.** — This insect continued to be the most serious pest of unsprayed apples on Vancouver Island.

**APPLE (AND BLUEBERRY) MAGGOT.** — Specimens were collected on hawthorn in the Morden, Thornhill, and Miami areas of Manitoba, and larvae, believed to be of this species, were noted on hawthorn at Brandon. Infestations remained light in sprayed orchards throughout Ontario. A general northwestward spread continued in Quebec, where severe infestations were reported from the Quebec, Neuville, St. Augustin, Champigny, St. Nicholas, and St. Roche



des Aulnaies district. Little change was noted in New Brunswick and Nova Scotia, where an expanded survey revealed more infested properties than in 1950, most of them being non-commercial orchards. Some apple varieties were severely infested in unsprayed orchards in Prince Edward Island but little general change was noted. Blueberries were more severely infested than in 1950 in New Brunswick, and light infestations occurred in Prince Edward Island.

**APPLE MEALYBUG.** — Small numbers continued to appear in the St. John River Valley, N.B., and in some Nova Scotia orchards.

**BLUEBERRY CUTWORMS.** — The population density of most cutworm species showed little change in New Brunswick, but the black army cutworm continued to decrease and the w-marked cutworm increased considerably.

**BUFFALO TREEHOPPER.** — This insect continued to be an economic pest in young plantations, notably in Quebec.

**CASEBEARERS.** — The cherry casebearer occurred as a minor pest in Quebec, as did the cigar casebearer, which was noted chiefly in neglected orchards and on wild apple. The latter species was reported to be scarce in Ontario.

**CHERRY FRUIT FLIES.** — Cherry growers on Vancouver Island, B.C., experienced the worst infestation of *Rhagoletis cingulata* (Loew) ever recorded on sweet and sour cherries, fruit infestation ranging up to 70 per cent in some orchards. Infestation was average on Prince Edward Island.

*Rhagoletis fausta* (O.S.) was numerous, mainly on sour cherries on Vancouver Island, and on pin cherry at Morden, Man. It was found for the first time in the Okanagan area, B.C., being observed in a single orchard near Westbank.

**CHERRY FRUITWORM.** — The cherry crop in the Kelowna, B.C., area was damaged to a greater extent than ever before by this insect.

**CHLAMISUS SP.** — An undescribed species of *Chlamisus* appeared as a new pest of strawberries in the Belleisle, Washademoak Lake, and Grand Lake areas in New Brunswick, where it caused serious damage. Larvae and adults are voracious feeders, the former attacking both foliage and fruit.

**CODLING MOTH.** — Damage to the apple crop in British Columbia was the greatest since the commercial introduction of DDT in 1947. Severe losses occurred in many areas, particularly at Salmon Arm, where 50 per cent of the crop was destroyed. Reduced spraying and weather conditions contributed to the increase. Infestation of apple and pear was the lowest in several years in southwestern Ontario, and remained low in commercial apple orchards in Quebec and New Brunswick. Considerable increase over the low of 1949 and 1950 was reported in Nova Scotia, particularly in the Minas Basin, and damage in general was almost double that of 1950.

**CRANBERRY FRUITWORM.** — This insect continued to be a common pest of cranberries in New Brunswick, where infestation in untreated areas usually runs from 50 to 80 per cent. Reduced infestation and light damage were reported from Prince Edward Island.

**CURCULIONIDS.** — The plum curculio occurred in a moderate infestation on plum at Morden, Man. Injury was the heaviest in several years on peach in the Niagara, Ont., area, and on peach, plum, and apple in Essex and Kent counties. Light damage occurred on plum in the Niagara district, and on apple in several small orchards in eastern Ontario. In Quebec, this curculio continued to be a major pest, particularly where control measures were not used, and the apple curculio remained a minor pest with the exception of at least one local outbreak in an orchard at St. Hilaire. An apple flea weevil, *Rhynchaenus pallicornis* (Say), for the first time on record in Canada caused noticeable foliage injury in an apple orchard in Norfolk County. The strawberry weevil occurred in light infestations at Morden, Man. In Quebec, it was troublesome in the Montreal and Quebec areas, but was appreciably reduced at St. Jean, where damage was light even in untreated plantations. Little change was noted in New Brunswick, some planta-

tions being seriously infested. Populations were somewhat larger than usual on strawberries and very light on raspberries in Prince Edward Island. Adults of the strawberry root weevil were abundant in dwellings at Pike Lake, Sask., and Birtle, Man. Some damage occurred on strawberries and apple seedlings at Morden, Man. The black vine weevil caused extensive damage to British Sovereign strawberry plants, even where apple pulp bait was used, on Vancouver Island. For the first time in British Columbia, *Barypeithes pellucidus* (Boh.) occurred in economic numbers, attacking the fruit and leaf buds of raspberry at Oak Bay, and *Plinthodes taeniatus* (Lec.) caused extensive damage to the foliage of strawberries at Sooke on Vancouver Island.

**CURRENT FRUIT FLY.** — Reports, about half as numerous as in 1950, were received from Carrot River, Battleford, Manitou Beach, Estevan, and Saskatoon in Saskatchewan. The pest was abundant in Manitoba.

**EYE-SPOTTED BUD MOTH.** — Populations in southern British Columbia were larger than in 1950, and cherries in the Kelowna area were severely injured. In Ontario, this bud moth was common but not abundant in eastern areas and in Norfolk County; a slight increase occurred in the normally small numbers in the Niagara Peninsula, and it was of little importance in Essex and Kent counties. It continued to be an important pest in Quebec, causing considerable damage in the Hemmingford, St. Hilaire, Rougemont, Abbotsford, and Montreal areas. Small orchards in New Brunswick were moderately to severely infested but a general improvement was noted. This bud moth ranked second to the codling moth in the Annapolis Valley, N.S., where slight, if any, increase occurred. General prevalence, as usual, was reported in Prince Edward Island.

**GRAPE BERRY MOTH.** — Infestation was light in the Niagara, Ont., area, but moderate damage occurred in most vineyards in Essex County.

**VARIOUS FRUITWORMS.** — Damage to fruit by so-called green fruitworms in most of Eastern Canada was the greatest in many years. Severe infestations of the spring and fall cankerworms occurred at Morden, and light infestations at Brandon, in Manitoba. In many Quebec orchards, green fruitworms caused more damage than any other pest, one particularly severe outbreak of the spring cankerworm being observed at Frelighsburg, and lesser infestations at Rougemont, Abbotsford, St. Hilaire, and Franklin. Fruitworm damage in Nova Scotia was the greatest in many years, the fall cankerworm causing complete defoliation of apple in some orchards at Falmouth, and considerable injury throughout Kings County. The lesser appleworm infested apple at Morden, Man.

**IMPORTED CURKANTWORM.** — Infestations were reported from Saskatoon and Carrot River, Sask.; Winnipeg, Morden, and Brandon, Man.; Charlottetown, P.E.I., where gooseberries were severely injured in old plantations; and Newfoundland.

**LEAFHOPPERS.** — The white apple leafhopper was of minor importance in orchards of Eastern Canada, but a severe infestation, apparently of this species, occurred in orchards at Salmon Arm, B.C. Grape leafhoppers caused no appreciable injury in Ontario. The potato leafhopper was reported to be abundant on apple at Morden, Man.

**LEAF ROLLERS.** — The fruit tree leaf roller continued to increase in the Okanagan Valley, B.C., where it caused serious injury to foliage and fruit of apple, and killed many seedling cherries. It was reported as a minor pest causing moderate damage in Quebec. The red-banded leaf roller was more prevalent and injurious than ever before in Essex, Kent, Norfolk, Durham, and Northumberland counties in Ontario; severe second-generation injury occurred in some orchards. A slight increase occurred in the Niagara Peninsula, where it was serious in only a few orchards. A sudden increase in numbers and spread over a wide area in southwestern Quebec was reported. It was the most important apple pest in the St. Jean area, and at St. Hilaire caused 75 per cent loss in one apple orchard and 10 to 50 per cent in others. Indications are that it may be the most serious apple pest in Quebec in 1952. In Nova Scotia, the gray-banded leaf roller occurred in many apple orchards and caused considerable damage in some; it is increasing in the Province. Present in many orchards in moderate numbers and causing minor damage were the leaf rollers *Archips persicana* (Fitch) and *Pandemis limitata* (Rob.).



*Archips rosaceana* (Harr.) continued to decline and was comparatively scarce. The strawberry leaf roller occurred in comparatively light infestations, after several severe infestations in 1950, in southwestern Ontario. Moderate injury was reported from Newfoundland.

**MITES.** — The European red mite, as in 1950, caused damage in only a very few orchards in British Columbia. It was generally less abundant than in 1950 on apple in Ontario but local minor increases were reported from Northumberland and Durham counties. On peaches and plums throughout southwestern Ontario, infestations were fairly light although a few orchards were damaged in July. Predators were abundant on plum in the Niagara area. In Quebec, populations were high in the St. Lawrence Valley, and in the Frelighsburg and St. Anne de la Pocatiere areas, but in general were somewhat reduced from those of recent years. Infestations remained comparatively light in Nova Scotia but built up in the few orchards in which DDT and parathion were used. Increases and some severe damage in the vicinity of Charlottetown, P.E.I., were reported. Populations of the two-spotted spider mite on cane fruit in the lower Fraser Valley, B.C., were exceptionally small, notwithstanding a record drought. They were small also on fruit trees in the Okanagan and Kootenay valleys although the pest had been serious in 1950. Considerable damage occurred on strawberries at Magna Bay, and on greenhouse tomatoes at Sorrento. In Saskatchewan, infestations of mites, probably chiefly this species, occurred on raspberries at Carrot River, Manitou Beach, and Saskatoon; on currants at Moose Jaw and Saskatoon; and on caragana at Saskatoon. This species was generally distributed in peach orchards in Ontario, causing little injury. Early defoliation occurred, however, on peach nursery stock. Populations were larger than in 1950 on apple in Northumberland and Durham counties. Some strawberry plantings were seriously injured at Oakville, Ont., and in the Niagara Peninsula, where one raspberry patch also was severely injured. In Quebec, infestation was reported to have spread far beyond previous boundaries to include the Quebec City area and the northern part of the Gaspé Peninsula, but the damage caused by this species remained well below that of the European red mite. In Nova Scotia it occurred only in trace numbers except in orchards where DDT and parathion had been used. The Pacific mite was much less numerous than in 1950 and of little importance in the Okanagan and Kootenay valleys, B.C. Control measures reduced a considerable infestation on red currants at Armstrong, B.C., where damage had been severe in 1950. The species was common on raspberries and currants in Manitoba. The clover mite was the most troublesome species in British Columbia orchards, particularly from Summerland south to the International Boundary. Before 1950 it was not considered a pest of fruit trees but in 1951 it developed to epidemic proportions in some orchards. A severe infestation occurred on gooseberries at Morden, Man., while in Nova Scotia populations remained at a low level. The pear leaf blister mite was present in medium to severe infestations in some orchards in British Columbia, and in Prince Edward Island, where it increased in numbers. *Eotetranychus flavus* (Ewing) caused damage in only a few orchards in British Columbia. *Phyllocoptes* spp. were more numerous than in previous years in British Columbia but caused no serious injury; some control was required at Kelowna. A mite, *Septanychus candensis* McG., was collected in several apple orchards in the Burlington-Oakville area and may have been confused with the two-spotted mite in previous years. The cyclamen mite caused considerable damage to strawberries in Manitoba, and *Eriophyes* sp. was common on plum and choke cherry.

**ORIENTAL FRUIT MOTH.** — The infestation was again at a low level in Ontario, and in Essex and Kent counties it was generally lower than in 1950, fruit injury averaging less than 1 per cent. In the Niagara district injury by first- and second-generation larvae was as light as or lighter than in 1950, and averaged less than 3 per cent. However, in the latter area "invisible" injury to Elberta was as high as 6 per cent where the last DDT spray was applied, and 18 per cent where it was omitted. Parasitism by *Macrocentrus ancylivorus* Roh. was at a comparatively high level, being somewhat higher than in 1950 in Essex and Kent counties, and slightly lower in the Niagara district.

**PEACH TREE BORERS.** — The peach tree borer was of minor importance in British Columbia. In Ontario a few orchards were severely infested in the Niagara district but infestation was generally low throughout the peach-growing areas of the Province. The lesser peach



tree borer continued to cause considerable damage in Essex County and increased over 1950 in several orchards. The peach twig borer caused serious losses to some apricot growers at Summerland, B.C., but injury to peaches was, in general, negligible.

PEAR PSYLLA. — Populations in British Columbia were comparable to those of 1950 and very little damage was caused. In Ontario, with the exception of Essex County, where damage was light, psylla populations were larger and harder to control than for several years.

PEAR-SLUG. — Infestations of outbreak proportions occurred in several orchards in the south Okanagan area, B.C. In Ontario, severe infestations almost defoliated many cherry and pear trees where control was inadequate in the Niagara district and Essex County. Minor damage occurred on cherries in Prince Edward Island, and the insect was recorded for the first time in Newfoundland where it damaged fruit trees and mountain ash at St. John's.

PLANT BUGS. — *Lygus spp.* were troublesome on peach and apparently increased in apple orchards in British Columbia, and typical injury increased somewhat on peaches in the Niagara Peninsula, Ont. The tarnished plant bug caused considerable fruit injury in strawberries at Morden, Man. *Neolygus communis novascotiensis* Knight caused minor damage, and *Campylomma verbasci* (Meyer) occurred generally and caused some fruit injury in apple orchards in Nova Scotia.

RASPBERRY CANE BORERS. — Reports of the raspberry cane borer were more numerous than usual in southwestern Ontario, and moderate damage occurred in the Chatham area. In Quebec, considerable damage was done in the St. Anne de la Pocatiere and St. Jean areas, while injury was light in the Hemmingford area. *Oberea affinis* Harr. was generally abundant in the larval stage in eastern Ontario and was apparently in the adult stage or at least not injurious in New Brunswick.

RASPBERRY FRUITWORMS. — Fruit bud injury on raspberry and loganberry, caused by the western raspberry fruitworm, was not serious in the lower mainland areas of British Columbia, the insect being effectively controlled.

RASPBERRY ROOT BORER. — Severe damage occurred in at least one raspberry planting at Saskatoon, Sask., where 60 to 70 per cent of the plants were infested.

RASPBERRY SAWFLY. — Typical damage was observed from Enderby south to Vernon and Lavinton in British Columbia; at Brandon, Man.; Maraora, Ont.; and Aylmer, Que.

ROSE CHAFERS. — The green rose chafer, usually found on wild roses, severely damaged raspberry buds at Lacombe, Sask. The rose chafer caused only minor injury in Norfolk Co., Ont., but larger and more widespread infestations were reported in Essex County.

ROUND-HEADED APPLE TREE BORER. — An occurrence on apple was reported from Winnipeg, Man., and in Quebec the borer caused the usual amount of damage to young trees and in neglected orchards.

SCALE INSECTS. — The oystershell scale remained at low population levels in British Columbia, Ontario, and Nova Scotia, but was reported as prevalent on unsprayed orchard and shade trees in Prince Edward Island. *Lecanium coryli* (L.) continued to increase in numbers and cause damage to pear and plum as well as to several varieties of ornamentals in British Columbia. In Ontario, the San Jose scale remained at a low level; the European fruit lecanium caused some damage to spy apple in eastern Ontario, and occurred in small numbers on peach and plum in the Niagara district; and the cottony peach scale continued to be injurious in several peach orchards in the Vineland-Jordan and Queenston areas of the Niagara district, where it appeared to be spreading; it was of little importance in Essex and Kent counties.

SPITTLEBUGS. — Strawberries in New Brunswick were infested by *Philaenus leucophthalmus* (L.) and *P. lineatus* (L.), both of which were prevalent. *Clastoptera saint-cyri* Prov., the species common on cranberries, was also prevalent on strawberries. *P. leucophthalmus* was reported to be very injurious, particularly to strawberries, in Nova Scotia.

**TENT CATERPILLARS AND WEBWORMS.** — Both the eastern and the forest tent caterpillars were very common throughout New Brunswick, severely damaging many orchards. In Nova Scotia the eastern species was fairly numerous and the forest tent caterpillar persisted in outbreak proportions in Kings and Hants countries, necessitating control measures. Tent caterpillars were not as numerous as in 1950 in Saskatchewan, although saskatoon was moderately infested in the Pike Lake area. In Manitoba, *Malacosoma lutescens* (N. & D.) was considerably less prevalent than in recent years. *Hyphantria texton* Harr. was not reported to be prevalent anywhere in Eastern Canada. The ugly-nest caterpillar was much less abundant than in 1950 in Manitoba.

**THRIPS.** — *Frankliniella vaccinii* Morgan was again very prevalent on commercially grown blueberries in Charlotte County, N.B., although some reduction in the population was indicated.

#### INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

**APHIDS.** — Aphids were generally prevalent throughout north-central areas of Saskatchewan. Caragana hedges were damaged at Blaine Lake, Laird, Cudworth, and Marcellin; maples were infested at Saskatoon and Summerberry, and from Saskatoon also reports were received of aphids on African violets, and of *Kakimia wahinkae* Hottes on delphinium; rose and honeysuckle were infested at Glen Ewen. In Manitoba, too, aphids were abundant on many plants, caragana and maple in particular being severely infested. Severe infestations of the melon aphid occurred on hothouse cucumbers in several greenhouses at Leamington, Ont. *Aphis viburnicola* Gill. was prevalent on snowball and high bush cranberry in New Brunswick.

**COLUMBINE BORER.** — Damage to columbine was reported from Winnipeg and Morden in Manitoba.

**FOUR-LINED PLANT BUG.** — This plant bug was very abundant on ornamental and mint plants in the St. Anne de la Pocatiere area of Quebec.

**FUNGUS GNATS.** — *Sciara coprophila* Lint. occurred on house plants at Basswood and St. James in Manitoba.

**LEAFHOPPERS.** — *Erythroneura* sp., prob. *ziczac* Walsh, was abundant on Virginia creeper and grapes in the Kamloops and Vernon areas of British Columbia, the infestation being the most severe on record at Vernon. Infestations were well controlled at Lethbridge, Alta. In Saskatchewan, Virginia creeper was considerably damaged at Saskatoon and North Battleford, raspberries also being attacked at the latter point. Leafhoppers, probably *Typhlocyba ariadne* McA., were common and injurious on roses in the Vernon, Kelowna, and Penticton areas of British Columbia. Leafhopper populations on roses, ornamentals, and shade trees were somewhat smaller than in 1950 in Prince Edward Island.

**LILAC BORER.** — Infestation of lilacs remained general at Morden, Man.

**LILAC LEAF MINER.** — This pest of lilacs is now distributed in varying infestations wherever lilac is grown in Quebec. Numbers were normal in Prince Edward Island and damage was severe in Newfoundland.

**MITES.** — In Manitoba, the Pacific mite occurred on roses, various ornamentals, and flowers, including hollyhock, at Morden, *Eotetranychus medanieli* McG. caused considerable damage to flowers in the Brandon area; and the cyclamen mite attacked cyclamen and strawberries at Morden and Brandon. In Ontario, the maple bladder-gall mite disfigured maples at Chatham, Port Lambton, and Merlin, being more prevalent than in previous years; and severe infestations of the two-spotted spider mite occurred on hothouse cucumber crops in Essex County.

**MOURNING-CLOAK BUTTERFLY.** — A single case of larval injury to weeping willow was observed at Chatham, Ont.

**NARCISSUS BULB FLY.** — This bulb fly continued to be a serious threat to the narcissus bulb industry in southwestern British Columbia, where infestation ranged as high as 60 per cent in untreated plantings in 1950.

ROSE CURCULIO. — Roses were damaged at Aylesbury and Saskatoon, Sask.; and at Morden and Brandon, Man., where infestations were lighter than in previous years.

SCALE INSECTS. — Damage by *Lecanium coryli* (L.) continued to increase on ornamental Japanese plum, maple, and May trees, as well as commercial pear and plum, in southwestern British Columbia.

SNOWY TREE CRICKET. — Various ornamentals and several small maples were injured at Chatham, Ont.

THRIPS. — The gladiolus thrips was not reported in Saskatchewan but was general from Manitoba eastward. Onion thrips caused the usual damage to hothouse cucumbers in Essex County.

WALNUT CATERPILLAR. — Many of the native black walnut trees in the counties of Essex, Kent, and Middlesex, in southwestern Ontario, were defoliated again in 1951.

#### INSECTS ATTACKING MAN AND DOMESTIC ANIMALS

BED BUG. — Several infestations were reported in Saskatchewan, Ontario, New Brunswick, and Prince Edward Island.

BLACK FLIES. — Populations were about normal in British Columbia, but for the first time on record in the Province cattle were severely attacked, the incident occurring in an area east of Lumby. Both branches of the Saskatchewan River in Saskatchewan were again heavily infested with *Simulium arcticum* Mall., which in past years caused considerable mortality among livestock. This year, however, there were no black fly outbreaks, presumably a result of control measures against the immature stages. *Simulium venustum* Say and *S. vittatum* Zett. continued to be the two predominant species attacking livestock along the smaller rivers in the Prairie Provinces, and on a few occasions caused severe annoyance. The Souris River and the tributaries of the Pembina River near Rock Lake in Manitoba were very heavily infested and control measures were required to prevent outbreaks. A great deal of annoyance to livestock did result, however. *Simulium meridionale* Riley and *Simulium luggeri* N. & M. were more abundant than usual in the Battle River Valley in Saskatchewan but apparently did not molest livestock. *Cnephia taeniatifrons* (End.) was relatively scarce along the Saskatchewan River. Black fly populations were somewhat larger and more troublesome than usual to livestock in Hastings and Peterborough counties in Ontario, and were reported to be abundant also in Prince Edward Island and Newfoundland.

BLACK WIDOW SPIDER. — Numerous specimens of this spider were received from the north and south Okanagan and the Kamloops district in British Columbia. It was more abundant than usual in Saskatchewan, where it was found only in the extreme southwest corner of the Province. There were no reports of attack on humans.

BLOW FLIES AND FLESH FLIES. — One case of human and three cases of animal myiasis were reported to the Kamloops, B.C., laboratory. *Wohlfahrtia vigil* Walk. and *W. opaca* Coq. were identified from one of the animal cases, and *W. opaca* alone from the second. The third case on animals appears to have been an infestation of *Calliphora* sp.

BOT FLIES. — *Gasterophilus intestinalis* (Deg.) occurred in moderate infestations in the Battle River Valley between Prongua and Battleford, Sask.; and *Gasterophilus* spp. were reported to be abundant on horses in Manitoba.

FLEAS. — Ten reports of *Ctenocephalides* spp. were received at Ottawa, and infestations were reported to be numerous at Summerside, P.E.I. Infestations of fleas, probably the European chicken flea, on poultry were reported from Rocanville and Allan, Sask., Ont., Alma and Clinton, and Sunny Bank, Que. A bird flea, *Ceratophyllus idius* Jord. & Roths., occurred in such abundance in a martin house at Ottawa, Ont., that the birds abandoned the nests.



**HORN FLY.** — The horn fly occurred in its usual abundance at Kamloops, B.C. In northern Alberta cattle were severely infested, particularly in the Gadsby area. Populations were reported to be normal in Manitoba and below normal in Prince Edward Island.

**LICE.** — Reports of the head louse on humans were received from Lethbridge, Alta., and Ottawa, Ont.; and *Pthirus pubis* (L.) was reported from Saskatchewan. The cattle biting louse was common in Manitoba. *Linognathus setosus* (Olf.) on dogs was reported at Grand Falls, Man., and at Stratford and Ottawa in Ontario. *Polyplax serrata* (Burm.) occurred on mice in a laboratory at Ottawa, Ont.

**MITES.** — The chicken mite, *Dermanyssus gallinae* (Deg.), was reported from Edmonton and Wainwright in Alberta; Glen Ewen and Saskatoon in Saskatchewan; and Morris, Stonewall, Altona, and other points in Manitoba. An infestation of mites, probably the hog follicle mite, *Demodex phylloides* Csokor, occurred on hogs at Charing Cross, Ont. Chiggers were reported to be a nuisance to cottagers in the Port Stanley, Ont., area.

**MOSQUITOES.** — Infestations were generally light in British Columbia in 1951, but frequent rains in Alberta and Saskatchewan resulted in large populations which persisted throughout the season in northern Alberta, and were a serious pest throughout Saskatchewan from May to July; outdoor work was almost impossible in extreme southwestern Saskatchewan in mid-June. *Aedes spencerii* (Theo.), *Aedes campestris* D. & K., and *Aedes flavescens* (Müll.) were the major species in the Dundurn and Dafoe areas. In Manitoba, dry weather resulted in light infestations. Populations were unusually large and persisted throughout the summer, severely attacking livestock, in eastern Ontario and western Quebec. Abnormal numbers were reported also from the Maritime area, where infestations were severe in May and June, and again in an unusual outbreak in August in New Brunswick.

**RAT-TAILED MAGGOT.** — A sheep-raiser in Dawson Creek, B.C., noticed that many of his sheep were coughing; one died and was found to have a rat-tailed maggot in one lung.

**SHEEP-TICK (Sheep Ked).** — The sheep-tick, or sheep ked, continued to be an important parasite of sheep in British Columbia, severe infestations building up where control measures were not applied.

**SNIBE FLIES.** — *Symphoromyia atripes* Bigot, which caused considerable annoyance to humans in Manning Park, B.C., in 1950, was scarce in 1951.

**TABANIDS.** — *Tabanus frontalis* Wlk., *Chrysops mitis* O.S., and *Haematopota americana* O.S. were prevalent during June, July, and August in the Saskatoon, Dundurn, Dafoe, and North Battleford areas in Saskatchewan, and were considered a moderate pest to man and livestock. *Tabanus* spp. and *Chrysops* spp. were much less abundant and less annoying to livestock than in several previous years in eastern Ontario. In Newfoundland, they were reported to be numerous and troublesome to man and livestock.

**TICKS.** — *Dermacentor andersoni* Stiles was particularly troublesome in the vicinity of Kamloops, B.C., where cattle were paralysed in herds that had never before been attacked; the number of paralysis cases is believed to have exceeded that of any previous year. A severe infestation occurred also in a small area in southwestern Saskatchewan. *Dermacentor albipictus* (Pack.) was as abundant as ever on horses and deer in British Columbia, and in coastal areas. *Ixodes pacificus* C. & K. appeared to be decreasing. A single report of a human being bitten by *Ornithodoros hermsi* W., H., & M. was received from Okanagan Landing, B.C. A survey of the status of the spinose ear tick, *Otobius megnini* (Dugès), in big game revealed its presence in about 50 per cent of the deer in the Kamloops, B.C., area. The American dog tick, *Dermacentor variabilis* (Say), was found for the second time in Alberta but in both cases the human carriers had just returned from Riding Mountain Park, Man., whence it is believed the ticks were carried. Small numbers of this species were reported from southwestern Saskatchewan, and it occurred on dogs and humans at Winnipeg, Man. *Ixodes sculpinus* Neumann was found in small numbers on ground squirrels in southern Saskatchewan.

WASPS. — Wasps of various species were reported to be unusually abundant in southwestern British Columbia, northern Alberta, Manitoba, eastern Ontario, and western Quebec. In Newfoundland, populations were greatly reduced from the high level reached in 1950.

#### HOUSEHOLD INSECTS

ANTS. — The invasion of lawns and dwellings by ants caused the usual amount of annoyance throughout Canada. The black carpenter ant, apparently was the most frequently reported species, causing considerable damage to cottages and dwellings, and even destroying telephone poles near Cypress River in Manitoba. The pharaoh ant was mentioned as occurring in dwellings, office buildings, and restaurants at various points in Ontario, Quebec, and Prince Edward Island.

BOXELDER BUG. — Adult boxelder bugs created more than the usual nuisance in and about dwellings in the Kamloops and Vernon districts of British Columbia during the fall.

BOOKLICE. — Reports of infestations included a chesterfield suite at St. John's, Nfld., and a winterized summer cottage and a basement apartment at Ottawa. The psocids were established in the stuffing of the chesterfield suite, and were apparently breeding between old shingles in the summer cottage. *Trogium pulsatorium* L. occurred at Vancouver in straw packing used in a shipment of material from France.

CARPET BEETLES. — The black carpet beetle was commonly reported throughout Canada and was possibly the major household pest; it was reported to be increasing in Alberta. As in recent years, *Anthrenus scrophulariae* (L.) occurred much less frequently than the black carpet beetle in Eastern Canada, and no reports were received from Western Canada in 1951. In fact, single reports from Saskatchewan in 1914 and Manitoba in 1940 constitute the only records from the Prairie Provinces on file at Ottawa. Damage to the hair on several violin bows at Oshawa, Ont., was believed to have been caused by carpet beetle larvae.

CLOTHES MOTHS. — Reports of infestations, though numerous and occurring in all of the provinces, continued to be greatly outnumbered by reports of carpet beetle infestations.

CLUSTER FLY. — Hibernating adults were a common household pest in Ontario and Quebec, and were reported to be troublesome during the last two years at Lethbridge, Alta.

COCKROACHES. — The German cockroach continued to be fairly frequently reported throughout Eastern Canada, but two reports from Saskatchewan constituted the only records from the Western Provinces. The oriental cockroach was also reported from Saskatchewan and was an occasional pest in Quebec. The only infestation reported in Ontario occurred in a food manufacturing plant in Brockville. *Parcoblatta pennsylvanica* (Deg.) was reported in the vicinity of Ottawa, Ont.

CRICKETS. — A mass migration of *Acheta assimilis* F. from grain fields to dwellings occurred at Vernon, B. C. Camel crickets, *Ceuthophilus alpinus* Scudd., were abundant in the basements of new homes in northern Alberta; and *Ceuthophilus* sp. was reported from Saskatchewan, and from Trenton and Ottawa in Ontario. The house cricket occurred in bakeries and institutions in Quebec, and was reported from Toronto, Ont.

CURCULIONIDS. — The strawberry root weevil was commonly reported as a pest in dwellings in northern Alberta, and occurred at Pike Lake, Sask., and Birtle, Man. It was reported from Lanark and Burnt River in Ontario, from several points in Quebec, and was numerous in Kings Co., N.S., and in Prince Edward Island. The black vine weevil was a pest in dwellings at Thetford Mines, Que., and St. John, N.B. *Barypeithes pellucidus* (Boh.) occurred in a house at Covey Hill, Que.

FLAT BUG. — *Aradus abbas* Berg. occurred in a residence at Schumacher, Ont.

FRIT FLY. — Large numbers of a species of the family Chloropidae entered a dwelling from cracks around a window frame in an unusual occurrence at Meaford, Ont.

GROUND BEETLES. — *Carabus nemoralis* Müll. and *Anisodactylus* sp. invaded a ground floor apartment in Ottawa, Ont.

HOUSE CENTIPEDE. — Specimens were received from Brockville and Belleville in Ontario.

HOUSE FLY. — Small populations were reported in Saskatchewan, Manitoba, and Newfoundland, but in many areas in most provinces difficulty was experienced in controlling strains of flies that had become resistant to DDT, and in some cases to other insecticides. Very large populations on a hog-raising ranch near Edmonton, Alta., persisted in spite of applications of various insecticides. In Ontario large populations developed in vine-crop canning areas, where they were apparently breeding in piles of decaying organic material, a by-product of the canneries.

MITES. — The clover mite occurred in dwellings at Nakusp, B.C., in the spring, and was a serious household pest in residential districts in Edmonton, Alta. Infestations were reported also from Chatham, Ont., and Montreal, Que. Bird mites, *Liponyssus silviarum* C. & F., invaded dwellings in Ottawa, Ont., and Montreal, Que.; and undetermined species of *Liponyssus* were numerous in an office building in Ottawa, and in a dwelling in Belleville, Ont., where children were bitten.

PLASTER BEETLES. — An infestation of *Coninomus nodifer* Westw. occurred in a new house in Halifax.

PHALAENID MOTHS. — *Stenira bicolorago* (Gn.), attracted to lights, occurred in some numbers in suburban dwellings at Ottawa, Ont.

SILVERFISH. — Many infestations were reported from numerous localities throughout Eastern Canada, and a few were reported from Saskatchewan.

SPRINGTAILS. — A persistent infestation occurred in a dwelling at Cacouna, Que., where the insects apparently were breeding in an uncemented area of the basement floor. Residences were invaded at Como, Que., and, for the second successive year, at Leitrim, Ont. Springtails, identified as *Sira buski* Lubbock, occurred in a house at Emerson, Man. Two infestations were reported from Saskatchewan.

WOOD BORERS. — *Lyctus brunneus* (Steph.) was collected at Ottawa, Ont., from a mahogany table imported several years ago from Scotland; the species is rare in Scotland and has not previously been reported in Canada. Other powder-post beetles, *Lyctus* sp., occurred at Ottawa and points in southwestern Ontario, and were reported to be numerous in eastern areas of Newfoundland. *Anobium punctatum* (Deg.) was reported from Blockhouse, N.S., and from Prince Edward Island. The wharf borer, *Nacerdes melanura* (L.), infested the basement of an office building at Ottawa, Ont., and cerambycids were reported to be severely infesting the timbers of a log club house at Cacouna, Que.

#### STORED PRODUCT INSECTS

STORED GRAIN INSECTS. — The season of 1951 was comparatively free from pests of stored grain. Considerable infestation had developed in 1950 in grain of United States origin placed in Canadian elevators in 1949. Much of this grain was fumigated in September, 1950, and although about 1½ million bushels of the stock was still on hand, no infestations were noted in 1951. Some infestations occurred in U.S. corn stored in Canadian elevators on the Pacific coast. This stock was placed in storage in 1949 and showed essentially no infestation in 1950. During 1951 it was necessary to carry out both fumigation and spraying to control the Indian-meal moth.



The Bay-Ports\* elevators remained essentially free from infestations of the Indian-meal moth. A routine program of inspection was continued and control measures were carried out when necessary.

Very few reports of weevil infestation in the wheat grown in southwestern Ontario was received.

The grain crop in Western Canada in 1950 was large, and a considerable amount was tough, damp, and frost-damaged. It was necessary to hold much of this material on the farms during the winter. Fortunately, there was an exceptionally large movement of grain in late winter and early spring, so that only slight losses resulted from insect damage. The harvest season of 1951 in Western Canada was very similar to that of 1950, possibly worse. The crop was large, and again there was much tough, damp, and damaged grain, providing suitable material for insect infestation. There was also a large amount of grain remaining in the fields unthreshed.

**MILL INSECTS.** — The insect problem in flour mills is receiving increasing attention. In many cases the mills are examined every month by inspector of the Division of Plant Protection. The Department of National Health and Welfare conducted a survey of flour mills in Ontario and Alberta in 1950 but, unfortunately, no examination of mills was carried out during 1951.

**SPIDER BEETLES.** — The control campaign against spider beetles has been continued in the Prairie Provinces and losses from these pests have fallen materially in the last two years. On the Pacific coast, *Ptinus ocellus* Brown is still the most important insect pest found in cereal warehouses. Considerable control work has been done, stimulated very largely by the educational campaign conducted by the Vancouver laboratory. Spider beetle infestations involving, *Ptinus villiger* (Reit.) and *Ptinus raptor* Sturm. occurred in a few cases in 1951 in Eastern Canada. Control measures with DDT yielded very satisfactory results.

**BEAN WEEVIL.** — This insect occurred in Ottawa, Ont., and Canterbury, N.B., and was reported to be common in Quebec and Nova Scotia.

**CADELLE.** — Small numbers were reported in Saskatchewan.

**CHEESE MITES.** — Mites were reported from several cheese curing plants in Eastern Canada. In most cases high temperatures were responsible for population build-up.

**CONFUSED FLOUR BEETLE.** — Moderate to severe infestations developed in mills and warehouses in Saskatchewan early in the year but were later brought under control. Infestations in stores and dwellings were frequently reported in most provinces.

**DRUG-STORE BEETLE.** — Infestations in stores and dwellings were reported from Matheson, Ont., Westville, N.S., Charlottetown, P.E.I., and various localities in Manitoba and Quebec.

**FLAT GRAIN BEETLE.** — Moderate infestations developed in mills and warehouses in Saskatchewan early in the year but were greatly reduced by control measures during the season.

**GRAIN MITES.** — *Tyroglyphus longior* Gerv. was reported to have caused some damage in granaries in northern Alberta. In Saskatchewan, mites, probably *Acarus siro* L., infested ground oats in two granaries and wheat in two others.

**GRANARY WEEVIL.** — Injury in Ontario, particularly to wheat in storage, was considerably less than in 1949 and 1950. The insect was not reported in Saskatchewan.

\* The "Bay Ports" originally referred to the grain storage ports on Georgian Bay, but the term is now used rather loosely to include all storage ports in the Great Lakes area except the Lake Head Ports on Lake Superior.

INDIAN-MEAL MOTH. — A severe infestation occurred at Vernon, B.C., in dried apple waste stored for the manufacture of strawberry weevil bait. Stored grain and meal were infested in a warehouse at Picton, Ont. Throughout Canada the insect was an important pest in packaged goods, notably cereals and pre-mix foods.

LARDER BEETLE. — Infestations in dwellings were reported from Saskatchewan; Ottawa and Long Branch in Ontario; Three Rivers, Granby and other points in Quebec; Marysville, N.B.; many homes in Prince Edward Island; and St. John's, Nfld. At Bryson, Que., major damage occurred in ten-test insulation in a church.

MEDITERRANEAN FLOUR MOTH. — The heated warehouse of a mill at Saskatoon, and a warehouse at Picton, Ont., containing grain and meal were infested by this insect.

SAW-TOOTHED GRAIN BEETLE. — This common stored food pest was possibly the most frequent contaminator of packaged foods in stores and homes throughout Canada. Its small size permits it to enter package through very small openings.

TOBACCO MOTH. — The continued use of 5 per cent DDT in tobacco storage warehouses brought about a further reduction in the degree of infestation caused by *Ephestia elutella* (Hbn.). Many warehouses are now essentially free from this pest.

WAX MOTH. — A severe infestation originated in stored bee hives in a basement and spread throughout the dwelling at Medicine Hat, Alta.

YELLOW MEALWORM. — Reports of infestations in dwellings were scattered and scarce with the exception of Kings County, N.S., where adults were reported to be numerous. It was believed that they originated outdoors rather than within the house.



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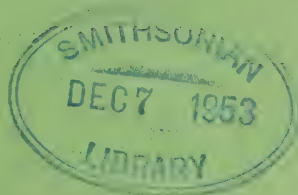
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## SOME ASPECTS OF RESEARCH AND DEVELOPMENT IN FUMIGATION IN EUROPE AND NORTH AFRICA<sup>1</sup>

H. A. U. MONRO<sup>2</sup>

*Science Service Laboratory, London, Ontario*

During the spring and early summer of 1952, in the course of an official investigation in Europe, visits were paid to a number of laboratories and installations in the United Kingdom and other countries where research or practical operations are conducted in the field of fumigation.

In Europe, as in North America, numerous problems have been solved by techniques employing poison gas. Fumigants have proved to be extremely adaptable for application in all kinds of structures, whether originally intended as fumigation chambers or not. Thus, insect control problems in ships, barges, railway freight cars, granaries, elevators, and warehouses, have been successfully solved by the use of poison gas. Portable devices such as tents and tarpaulins developed for various purposes have enabled fumigants to be used in the field. To this list we may add specially designed fumigation chambers, used either at atmospheric pressure or under vacuum. The widespread application of gaseous agents to the soil has recently opened up an entirely new field of research and development.

In view of the wide scope of this subject it was only possible to cover a limited field in each country visited. The subject matter of this report has been arranged according to countries.

As vacuum fumigation presents an interesting study in the differences in technique from one country to another, a special account is given of this subject.

### TECHNIQUES OF VACUUM FUMIGATION

It is probable that vacuum fumigation was first employed in a practical way in the United States about 1912, being developed almost simultaneously by D. B. Mackie in California and E. R. Sasser and L. A. Hawkins of the United States Department of Agriculture.

At first, it was the opinion of Mackie and others that best results would be achieved by the so-called "dissipated" vacuum technique. This consisted essentially of drawing an initial vacuum of about 60 mm. of absolute mercurial pressure in a specially designed fumigation tank. On reaching the required vacuum, the needed amount of fumigant was dispensed into the chamber according to the particular treatment desired. Immediately after the introduction of the poison gas, atmospheric air was allowed to flow into the chamber to restore the pressure almost to that of the outside atmosphere. In actual practice atmospheric pressure was not attained, it being desirable to retain a slight vacuum of about 600 mm. of pressure inside the chamber to prevent leakage of the fumigant to the outside air. This arrangement also ensured that the door of the chamber remained closed during the fumigation period, and was additional security to the use of clamps and bolts. This technique is now also referred to as the "vacuum released" method.

Subsequently, workers in the United States, and we ourselves in Canada, observed that far more effective results were obtained with a number of products if the vacuum was retained in the chamber after the introduction of the fumigant, for the duration of the fumigation period. This technique came to be known as the "vacuum sustained" method. Observations of an apparent superiority of the new technique were subsequently confirmed in laboratory work by Cotton, Latta, Lindgren, Crumb and Chamberlain, and others in the United States, and ourselves in Canada (see review by Monro, 1941). Thus, about fifteen years ago, as far as North America was concerned, it was established that for a number of non-perishable commodities so

<sup>1</sup> Contribution No. 11. Science Service Laboratory, Canada Agriculture, London, Ontario.

<sup>2</sup> Senior Officer, Fumigation Unit.

far encountered, together with their appropriate insect pests, the vacuum sustained method was the most efficient for applying the commonly used fumigants, such as hydrocyanic acid gas, methyl bromide, and ethylene oxide.

It must be pointed out, however, that treatments of fresh fruits, vegetables, growing plants, and most dormant nursery stock must be conducted either with the released vacuum or at atmospheric pressure, because sustained pressures below 300 mm. of mercury may be injurious to living plant tissues.

In visits to France and North Africa, it was found that French manufacturers of vacuum fumigation equipment are installing vacuum fumigation plants based on a refinement of the released vacuum technique. This refinement consists not of following the fumigant with a stream of air, but of allowing the fumigant in a gaseous form to be mixed evenly with the inflow of atmospheric air, so that a constant proportion of fumigant to air is maintained until the entire dosage has been introduced. Here again, the flow is so arranged that a slight vacuum is left in the chamber to ensure that the doors will not come open and the fumigant escape. This technique has been investigated and reported on by A. Lepigre of Algiers (1934), and is discussed fully in his book on vacuum fumigation (1949). It is referred to by this worker as "La méthode des introductions simultanées", or the method of "simultaneous introduction" (Fig. 1).

In practice, this method of simultaneous introduction calls for extra equipment in a vacuum fumigation plant, as it is necessary to provide a gasholder or gasometer to hold the fumigant in the gaseous form so that it can be introduced simultaneously with the air in the correct proportions.

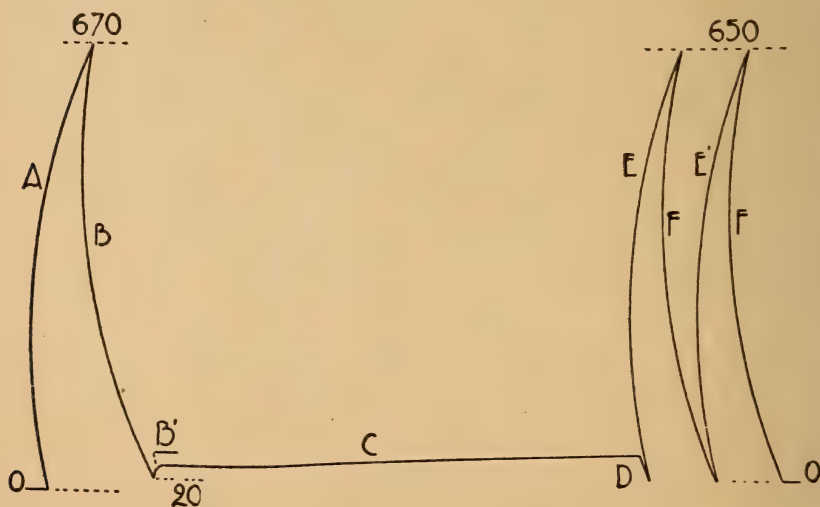


Fig. 1. — Diagramme de la méthode des introductions simultanées.

A : Vide de 0 à 670 mm. — B : Introduction du mélange insecticide de 670 à 20 mm. — B' : Remontée de vide en fin d'introduction. — C : Séjour sous vapeurs (désinsectisation). — D : Introduction d'air de 20 à 0. — E, E' : Vides de 0 à 650 mm. — F, F' : Introductions d'air pur de 650 à 0. (Orig.).

#### Diagram I

Figure 1. Vacuum Fumigation. Diagram (I) illustrates the method of "simultaneous introduction", diagram (II) the "vacuum sustained" technique. Pressures in millimeters of mercury. (From Lepigre)

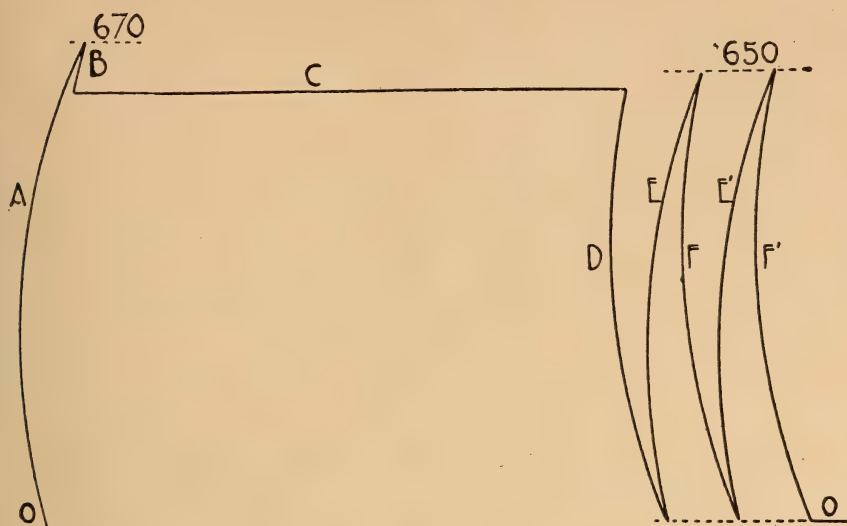


Fig. 2. — Diagramme de la méthode **élémentaire** ou **américaine**.

A : Vides de 0 à 670 mm. — B : Introduction de fumigant pur. — C : Séjour sous vapeurs (désinsectisation). — D : Introduction d'air jusqu'à 0. — E, E' : Vides de 0 à 650 mm. — F, F' : Introductions d'air pur de 650 à 0. (Orig.).

Diagram II

- A. Initial evacuation of chamber.
- B. Introduction of fumigant: In (I) the fumigant is introduced in a stream of air until pressure is returned almost to that of the atmosphere; in (II) the fumigant is not diluted during the "sustained" treatment.
- C. Period of fumigation.
- D. Introduction of air at end of exposure.
- E, E'. Successive evacuations for "air washing".
- F, F'. Successive introductions of air for "air washing".

In the United Kingdom, research teams under W. Burns-Brown at the Pest Infestation Laboratory at Slough, and under A.B.P. Page at the Imperial College field station near Ascot, are at present conducting experiments with a number of different products to compare the efficiency of the two techniques.

In Germany, the fumigant manufacturing concern "Degesch" has developed vacuum fumigation equipment based on the principle of the sustained vacuum, with a further refinement brought about by a recirculating system to keep the fumigant under continuous movement during the first half-hour of the exposure period, so as to ensure its even distribution.

A scientific basis and explanation for the believed superiority of the vacuum sustained method lies in the independent observations of Cotton (1932) and of Moore and Carpenter (1938), who found that oxygen deficiency increases the susceptibility of insects to fumigants.

In vacuum fumigation a serious problem is that of obtaining an even distribution of the fumigant throughout the chamber and within the product undergoing treatment. The method of simultaneous introduction obviously ensures a homogeneous mixture of fumigant and air



external to the load. However, in addition to the biological effects mentioned, it also appears that there are certain physical chemical factors influencing the rate of penetration of lethal concentrations, which favour the use of the vacuum sustained method with a large number of commodities so far investigated.

## RESEARCH AND DEVELOPMENT IN DIFFERENT COUNTRIES

### A. UNITED KINGDOM

#### (i) *Pest Infestation Laboratory*

The Department of Scientific and Industrial Research maintains a large laboratory at Slough, Buckinghamshire, known as the Pest Infestation Laboratory; G. V. B. Herford is the Director. One of the departments of this laboratory is the Fumigation Section under the leadership of W. Burns-Brown. This section consists of a team of ten professional workers and technicians. The work of this section, in accordance with the terms of reference of the Pest Infestation Laboratory as a whole, deals with what might be termed "industrial fumigation". Thus they are dealing mostly with stored product pests and related problems. The work of the section is divided into two, one part of the staff working on basic research on fumigants under laboratory conditions, and the other, under H. K. Heseltine, is a field unit. This unit is equipped with a mobile fumigation laboratory and works largely in the field testing new developments in fumigation application, usually based on the results of the work of the laboratory section. In this way it is felt that the section as a whole is kept in touch with field conditions and problems.

For the laboratory testing of fumigants, the section is equipped with two steel chambers of approximately 1700 litres capacity. Each of these chambers is housed in air-conditioned rooms, so that treatments at two levels of temperature can be investigated simultaneously. The chambers are well-equipped for gas analysis studies and the withdrawal of exposed insects. They can be used for vacuum or atmospheric fumigation tests.

The work of the fumigation section, in common with the rest of the laboratory, is largely integrated with the activities of the British Ministry of Agriculture and Fisheries, in the practical pest control work supervised by the Division of Infestation Control. The work of this division is described below.

Other sections of the Pest Infestation Laboratory are those of Biology, Grain Storage and Mycology, Insecticides, and Biochemistry. The latter section has recently been working on the biochemical aspects of fumigation, principally those concerned with the use of methyl bromide.

#### (ii) *Imperial College of Science and Technology, Biological Field Station, Silwood (near Ascot), Buckinghamshire*

The work of this laboratory lies under the direction of J. W. Munro, Head of the Department of Zoology. This department is mainly concerned with applied entomology and has on its staff A. B. P. Page and O. F. Labatti, both of whom have made extensive contributions to our knowledge of fumigation. As the Slough Laboratory is concentrating mainly on stored product fumigation problems, this team is studying principally the application of fumigants to agriculture.

The laboratory at this station is organized for the work of advanced research workers and also for the training of graduate students.

The entomological laboratory is housed in a converted mansion and there is ample space for the fairly extensive program of fumigation research. Problems in hand at present include a study of the vacuum fumigation technique, the absorption of fumigants by soils, the fumigation of potatoes and other agricultural products with methyl bromide, and methods of fumigant analysis. Recently a new method of detecting methyl bromide in low concentrations has been devised, using a linear reaction on test papers rather than a flame colouration (Call, 1952).

(iii) *Ministry of Agriculture and Fisheries,  
Division of Infestation Control*

The control of infestation in products imported into the United Kingdom comes under the above organization. Actually, in its entirety, this division also deals with other problems, such as the control of rats. The Director is W. McCauley Gracie. His chief scientific assistant is J. W. Evans and J. A. Freeman is Chief Entomologist. The work of the division is divided into



Figure 2. Consignment of cocoa beans awaiting fumigation, Port of London.



two sections, one dealing with rodents and the other with insect infestation. This division is empowered to inspect and retain for treatment, if required, only foodstuffs being imported through the agency of or for the account of the British Ministry of Food. In the case of private importations, which at present form a very small percentage of the food entering the United Kingdom, the inspectors of the division often examine these and advise the importer if they consider some treatment should be carried out: the recommendations of the inspectors are usually followed, but it must be emphasized that under the present system the government authorities do not insist on the treatment of private importations.

In addition to the supervision of material at the time of importation, the inspectors of this Division are also responsible for the supervision of storage facilities. In this way, a check is kept on the material until it is delivered for processing.

In the United Kingdom, at the large ports where imported foodstuffs are unloaded, barges are used extensively for treating a wide range of products. As the British barge is admirably suited for fumigation work, it plays much the same role as the Canadian railroad car in the organization of the pest control program in imported plant products (Figs. 2, 3).



Figure 3. Applying methyl bromide, barge fumigation of cocoa beans, Port of London.

Grain storages in the United Kingdom are often unsuited as structures in which fumigation of bulk grain may be carried out. Thus much of the grain found to be infested is treated in the barges used for transporting it to the storages (Fig. 4). Although experimental work has shown that it is difficult to obtain a good distribution of methyl bromide in bulk grain, the



Ministry authorities are satisfied so far with the practical results of fumigation in barges with this gas introduced from jets above the surface of the grain. Some grain is also treated in railway "waggons" (box cars and open cars) under rubberized or plasticised tarpaulins.

Most of the fumigations are carried out by pest control companies specializing in this type of work.

#### B. FRANCE AND ALGERIA

In France and French North African territories, the principal line of fumigation development has been the erection of numerous vacuum fumigation installations, mostly at the larger sea ports. Those in France are concerned mainly with the treatment of imported fruits, vegetables, and nursery stock. The numerous stations in North Africa have been designed principally for the fumigation of outgoing cargoes of dates and figs, of which large quantities are handled annually, and for importations of nursery stock.

The independent research on fumigation has been done largely in the entomological laboratory at Algiers by Dr. A. Lepigre and his associates.

##### (i) *Organization of the Plant Protection Service in France*

In Paris an interview was held with Mr. Paul Dumas, Chief of the Plant Protection Service of the French Ministry of Agriculture (Service de la Protection des Végétaux). This service covers a rather wide range of activities including the inspection and control of importations of plants

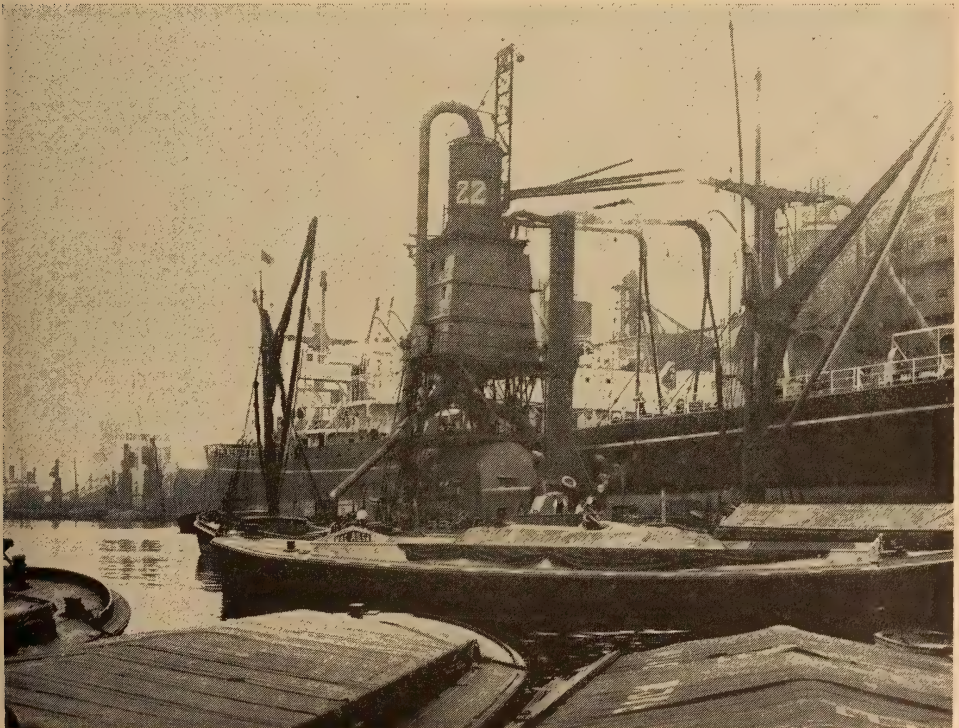


Figure 4. Milwall Dock, Port of London. Floating suction tower unloading Australian wheat into barges for fumigation.

and plant products, the examination of exported plant material, and, in addition, the actual carrying out of domestic plant disease and insect control programs. This work is largely of an extension nature, in that advice is given to farmers, and propaganda work of one kind or another is carried on.

Vacuum fumigation plants at ports of importation in France, therefore, fall under the control of this division. At present the one at Le Havre is the only one actively functioning, but others are in the course of construction, or proposed, at Nantes, Dunkirk, Bordeaux, Marseilles and on the Franco-German frontier at Strasbourg.



Figure 5. Fumigation Station, Le Havre. Chamber for treating railroad cars under released vacuum.

(ii) *Fumigation Station at Le Havre*

The port of Le Havre was almost completely destroyed during the last war and an opportunity has been afforded for the erection of very modern facilities throughout. Not least among these is a new fumigation station. This has been supplied with adequate tracking and road facilities.

The installation is built around the vacuum released technique with simultaneous introduction of gas and air. There are four steel vacuum fumigation autoclaves of 706, 1095, 1765, and 2647 cubic feet internal capacity. Evacuation of the air is effected by a battery of rotary pumps. The rotary pump is popular with French engineers for vacuum fumigation, as opposed to the reciprocating type usually found in American and Canadian installations. An interesting feature of the vacuum chambers is the special provision of waterfilled door gaskets. After the door is closed, the automatic equipment is turned on and water forced, under pressure, into



the hollow tube of the gasket. This ensures that a very tight seal is made between the wall of the tank and the door. Of course, this precaution is made more necessary by the fact that the vacuum is released almost to atmospheric pressure by the simultaneous introduction of gas and air. The installation was made by Mallet S. A. of Paris.

The large outdoor concrete chamber (Fig. 5) was designed for fumigating, under released vacuum, an entire railroad car and its contents.

(iii) *Fumigation Station at Algiers*

Under the auspices of the various French-controlled regimes in North Africa, numerous vacuum installations have been made at key points in the date-, fig-, and tobacco-growing regions, and also at the ports of exportation such as Casablanca, Oran and Algiers.

In Algiers is one of the largest vacuum fumigation installations in the world. Here are vacuum tanks with capacities of 70, 140, 350, 700, 1765 and 2470 cubic feet respectively (Figs. 6, 7, and 8). This installation was also made by Mallet S. A. of Paris.



Figure 6. Fumigation Station, Algiers. Entrance to tanks on "dirty side".  
(Photo courtesy A. Lepigre.)

In the background of Figure 8 the gasometers are clearly shown. The one on the left is for methyl bromide, the other for ethylene oxide. Owing to its high solubility in liquids, HCN cannot be handled by a gasometric method and is dispensed from a reaction tank by the chemical reaction of sulphuric acid and sodium cyanide.

A remarkable feature of the Algerian installation is the large amount of space devoted to the fumigation station itself. This permits handling and storing of large quantities of goods before and after fumigation.



Another feature of this and other French installations is the fact that the incoming infected goods are completely separated from the treated goods by a wall through which the tanks are built. The advantages of such a layout need no elaboration.

(iv) *Fumigation Research Laboratory, Algiers*

The research laboratory where A. Lepigre and his associates carry out work on fumigation is situated at the insectary of the well-known Jardin d'Essai (Botanical Gardens) of Algiers.



Figure 7. Fumigation Station, Algiers. Discharge doors of tanks on "clean side".  
(Photo courtesy A. Lepigre.)

The fumigation laboratory is separated from the rest of the insectary in a self-contained building partly below ground, in an effort, in the Algerian climate, to maintain a fairly constant temperature.

Here Lepigre and his associates have carried on fumigation research for over twenty years. A recent contribution has been made from studies of the effect of fumigants on the diastasic fermentation of vegetable products. Lepigre, in collaboration with M. A. Bobier (1952) has demonstrated that the curing of tobacco can be reduced from several weeks to a few days by treating it with ethylene oxide in a suitable chamber.

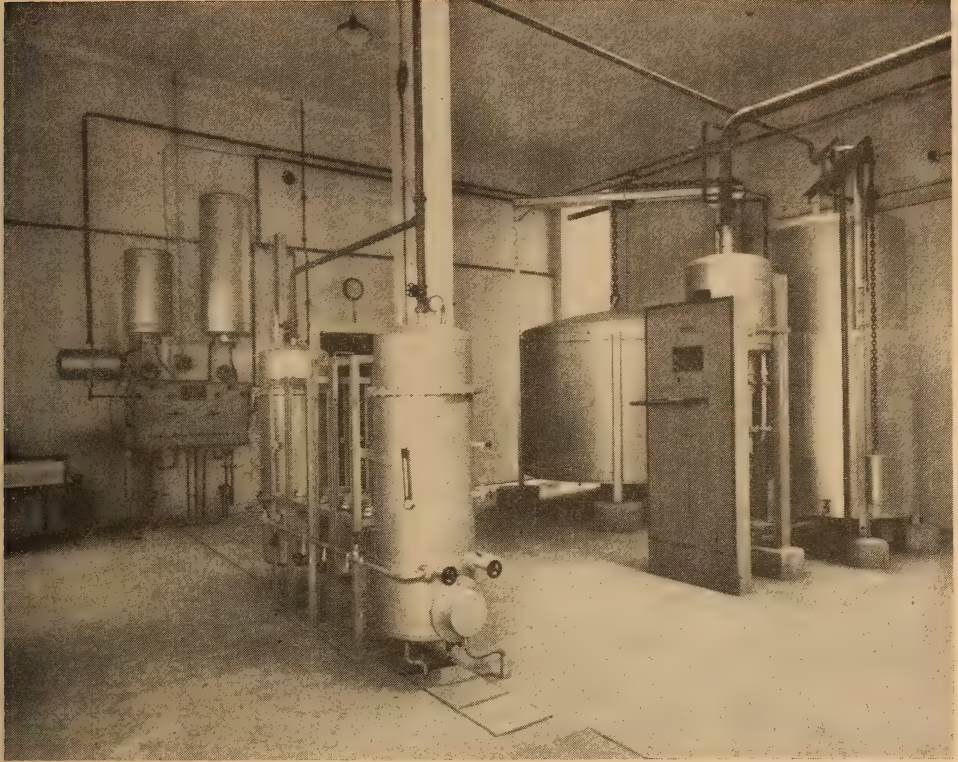


Figure 8. Fumigation Station, Algiers. Gasometers for dispensing methyl bromide and ethylene oxide. (Photo courtesy A. Lepigre.)

### C. SWITZERLAND

A visit was paid to Switzerland to inspect the permanent fumigation systems set up in grain elevators (silos) belonging to and operated by the Swiss Federal Grain Administration (Administration Fédérale des Blés).

The history of the organization of this permanent system of fumigation in grain silos dates back to the World War of 1914-18. Before this time all grain storage was in private hands, but during the war grave problems of infestation, resulting from prolonged storage and associated difficulties, caused the government in 1922 to introduce legislation to allow for the erection of their own silos.

About half of the Swiss grain for human consumption has to be imported from abroad, and before 1939 it was necessary to attempt to lay in stores sufficient for several years' consumption.

In 1939, as war was once again expected, the importation of grain was considerably increased and it was decided to install fumigating apparatus. The actual designs of the installations in the silos are based on some original German plans developed for use with Cartox (a mixture of ethylene oxide and carbon dioxide). However, results with this were not completely satisfactory and the Swiss authorities were also faced with the problem of supply of fumigants in case of war. A Swiss manufacturing concern had already undertaken the manufacture of methyl bromide and after some preliminary work by P. Benz of Zurich, consultant to the Administration, it was decided to use this gas in the silos. For the reason explained below, the fumigant used contains 90% methyl bromide and 10% carbon dioxide.

There are now about sixteen of the government-owned silos which are equipped with the permanent fumigation installation, and there are also a number of privately owned ones which have adopted the equipment.

As will be seen from the illustrations, the Swiss silos are usually built on a rectangular plan and the individual bins are thus square or rectangular. A typical bin is 70 feet deep and 12 x 12 feet square. Much of the work is carried out by automatic controls, and in most of the silos there are only two permanent employees on duty.

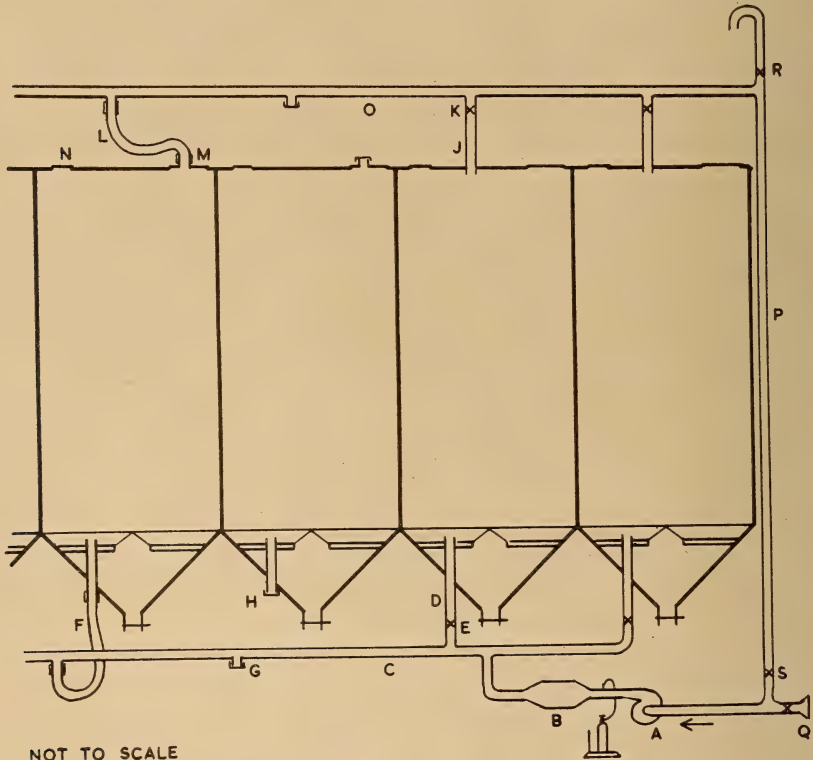


Figure 9. Swiss Federal Grain Administration. Diagram of Fumigation System in silos. (Photo courtesy H. M. Government, D.S.I.R.)

- (A) Blower with centrifugal fan.
- (B) Steel expansion chamber.
- (C) Manifold pipe running below bins.
- (D) Fixed pipe installation with shut-off valve (E).
- (F), (G), (H) Installation for flexible, detachable pipes.
- (J), (K) Fixed pipe installation at bin top.
- (L), (M) Flexible pipe installation at bin top.
- (P) Recirculation pipe.
- (Q) Fresh air intake.
- (R) Exhaust valve to roof.
- (S) Shut off valve for recirculating system.

At the base of each bin is a counter grading device and, periodically, grain is drawn off from the bin through this device in four streams. By this means significant increases in temperature in each of the four quadrants of the bin can be detected and the possibility of this being associated with insect infestation gives warning of the need for fumigation.



Concrete bins are the most common. However, in some silos steel bins are installed. In the early days of the fumigation program some difficulty was encountered with gas leakage through the porous cement walls. This has been corrected by the use of internal bituminous coatings, covered by two layers of rubber-based paint.

The general layout of the fumigation system is illustrated in Figure 9. The fumigant dispensing machinery is always installed in the floor below the bins. By means of a system of piping the fumigant (Figs. 12 & 13) may be carried to any desired bin in the silo and exhausted therefrom at the end of the exposure period. By manipulation of the appropriate valves, recirculation of the fumigant may be carried out as desired.

The usual dosage of methyl bromide applied is 15 grams per cubic meter. The flow of the fumigant from the gas cylinder is regulated by a flowmeter, which in turn is controlled by a concentration meter set up in the piping. This concentration meter works on the principle of the thermal conductivity of  $\text{CO}_2$ ; hence the need for this gas to the extent of 10% of the fumigant mixture. The fumigant flows into the expansion chamber (Fig. 10) and is then in-

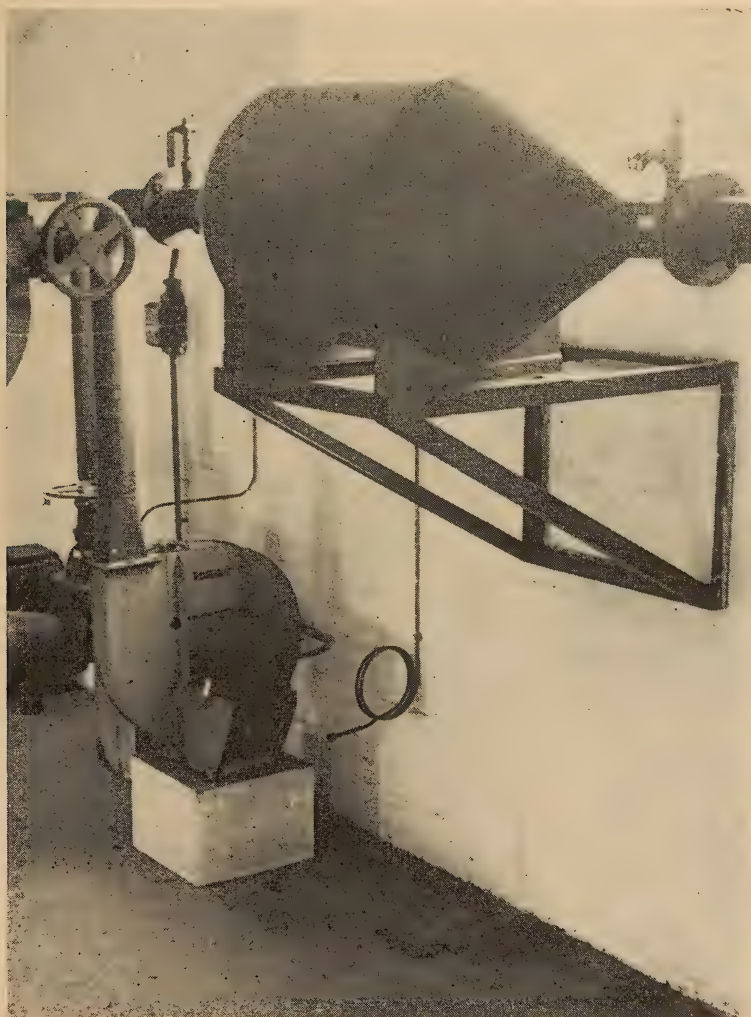


Figure 10. Swiss silos, steel expansion chamber, with blower and attachment for methyl bromide cylinder. (Photo courtesy H. M. Government, D.S.I.R.)

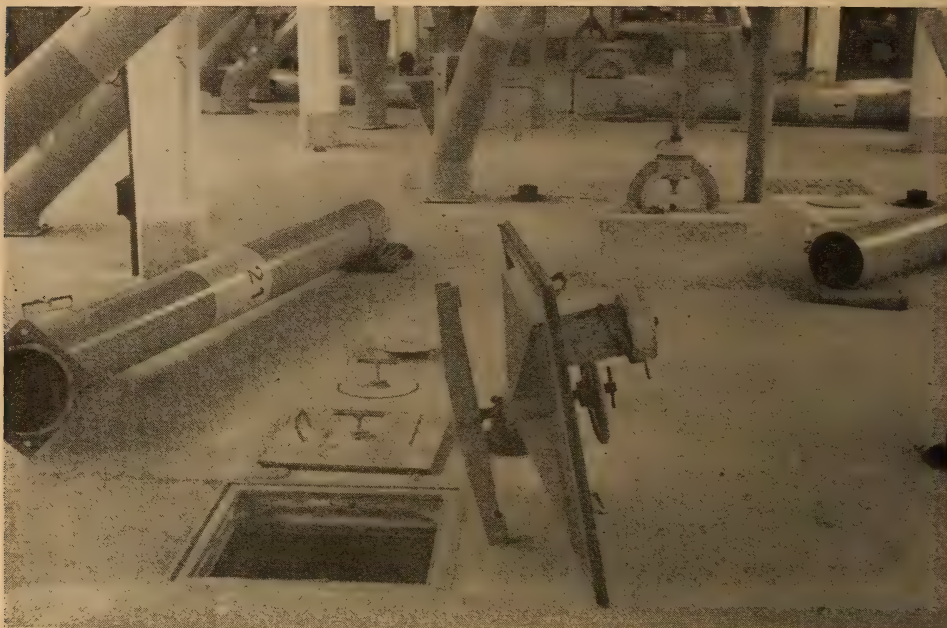


Figure 11. Swiss silo, special manhole for sealing bin when flexible piping installation used. (Photo courtesy H. M. Government, D.S.I.R.)



Figure 12. Swiss silo. Permanent fumigation piping above bin. (Photo courtesy H. M. Government, D.S.I.R.)



corporated with the air stream moving by recirculation throughout the whole system. Recirculation is usually continued for two hours after the dosage is applied, and under normal conditions the exposure period is 48 hours. At the end of the fumigation, the gas may be discharged through the exhaust system directly out through the roof or sometimes through a flexible pipe attached to the dust aspiration piping. If more than one bin is to be fumigated at about the same time, it is customary not to exhaust the fumigant but to divert it to another bin. By means of the concentration meter it is possible to restore the required dosage of fumigant. However, this restoration is never repeated more than two or three times with the same original dose of fumigant.

Before fumigation the ordinary manhole cover is replaced by a special cover with a rubber gasket and a device for clamping it down (Figure 11). Special provision is made for sealing the holes of the grain delivery and grain outlet pipes. It is usual practice to test the individual bins for gas tightness by attaching a water manometer to an inlet tube and operating a blower.

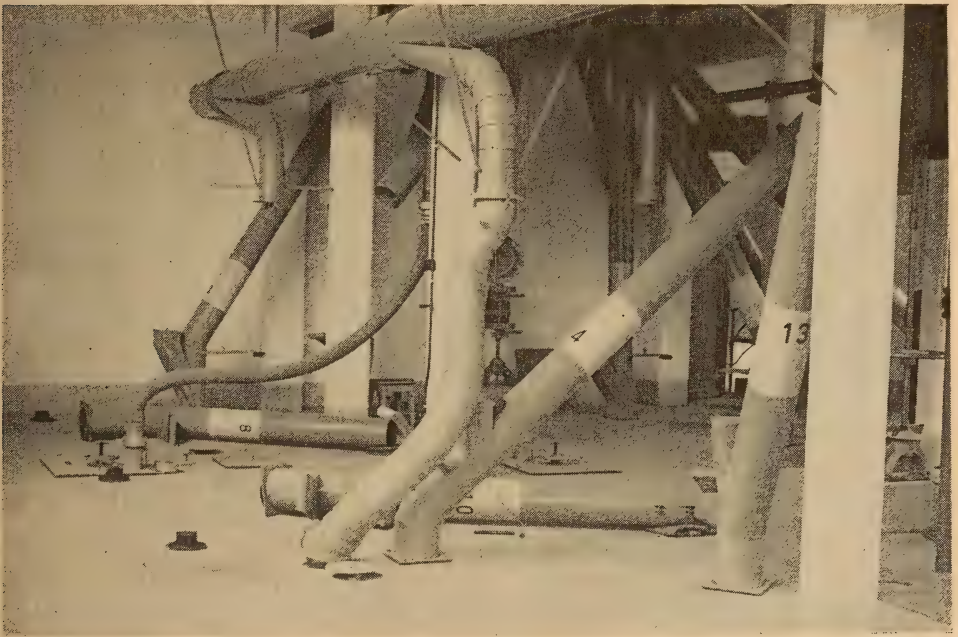


Figure 13. Swiss silo. Flexible fumigation piping, with special bin cover, above bins. (Photo courtesy H. M. Government, D.S.I.R.)

If a pre-selected height on the water gauge is not reached in five minutes, it is suspected that there is a leakage in the system and appropriate measures are carried out.

The recirculating motor employed is a fairly low-powered one of 3–4 horsepower operating a centrifugal fan. Such a blower is capable of moving 200 cubic feet of air per minute through a given bin.

#### D. GERMANY

During a short time spent in Germany, a visit was made to the laboratories and plant of the fumigant manufacturers and distributors, Deutsche Gesellschaft für Schädlingsbekämpfung (Degesch) at Frankfurt am Main. This company designs and supplies vacuum fumigation chambers. The "Degesch system" for vacuum fumigation is based on the sustained vacuum technique, supplemented by a recirculating system. To their vacuum chambers is added a pipe



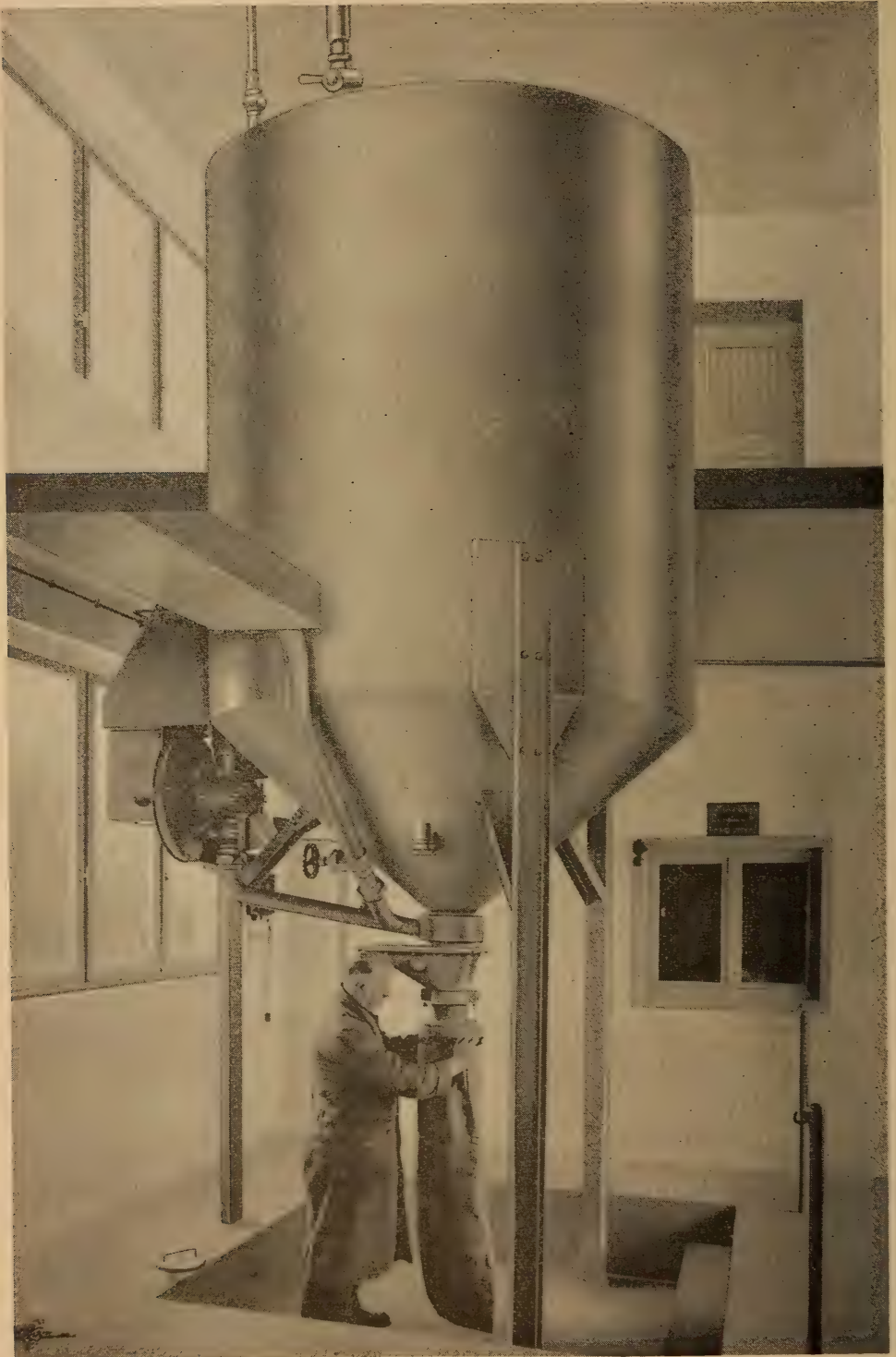


Figure 14. Five-ton grain storage and treatment silo (Degesch).

line by means of which continuous circulation of the fumigant is maintained during the first half hour of the exposure period. It is claimed that by this method problems of gas distribution are overcome and full advantage is taken of the biological effects of the sustained vacuum. This company also manufactures mobile vans for fumigating nursery stock.

A steel five-ton storage silo manufactured by this concern is illustrated in Figure 14. This silo can be used for the storage of grain or seeds and is equipped with a small-scale circulation system and is also being sold as a supplement to grain storage for the purpose of treating grain in small lots. There is no doubt that such a silo would find a useful place in many control operations against grain and seed infesting insects. It can also be adapted for developmental research.

#### ACKNOWLEDGEMENTS

The author wishes to acknowledge the many courtesies extended to him by officials in the countries visited, and their kindness in making arrangements for the various visits. The rather extensive journeys necessary to visit Swiss silos with features of special interest were arranged by Mr. H. Keller, Assistant Director, Swiss Federal Grain Administration. Transportation was generously afforded by the same authority.

At many places it was possible to take photographs. However, some visits were made at times or under conditions when lighting was unfavorable. The photographs of the Swiss installations are by courtesy of Mr. G. V. B. Herford, Director, Pest Infestation Laboratory, Slough, England who supplied prints of photographs taken previously by members of his staff, Messrs. W. Burns-Brown and H. K. Heseltine. Pictures of the Algerian installations were kindly presented by Dr. A. Lepigre.

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### CUTWORM CONTROL WITH ALDRIN, DIELDRIN, ENDRIN AND ISODRIN IN BRAN-WATER BAITS

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During 1951, Mitchener (1952) used aldrin, dieldrin and endrin (Hyman compound 269) in bran-water baits in the ratio of one part of each insecticide to 41, 83 and 166 parts bran respectively and obtained excellent cutworm control at the end of 72 hours in each instance. The results indicated that experiments with further dilutions should be undertaken and these were carried out during late May and early June in 1952. A fourth insecticide isodrin (Hyman compound 711) was included in these experiments.

**MATERIALS.**—Half-grown or larger cutworm larvae, probably mostly the red-backed cutworm, *Euxoa ochrogaster* (Guen.), were collected locally as needed and kept at approximately 40° F. until shortly before being used. The basic ingredients in the baits were bran and water in equal amounts by weight. Aldrin (Sample No. 9561, 23 per cent aldrin equivalent emulsifiable concentrate), dieldrin (Sample No. 9562, 18.5 per cent emulsifiable concentrate), endrin (Sample No. 9563, 18.5 per cent emulsifiable concentrate) and isodrin (Sample 9564, 18.5 per cent emulsifiable concentrate) were each added to the basic ingredients at the rate of one part actual insecticide to 166, 333, 666 and 1333 parts of dry bran respectively. The check groups of cutworms were fed on the bran-water mixture.

All experimental lots of cutworms were placed in open, clean, circular tin containers with straight sides, approximately 10¼ inches in diameter and 1½ inches deep, from which they were unable to escape. All bait experiments were carried out in a room where the recorded temperature ranged from 68° F. to 80° F. and the relative humidity from 26 per cent to 39 per cent. Poisoned bait from the same sample, which had been kept tightly covered, was fed to the cutworms in each of the four replicated experiments.

**METHODS.**—The method used in carrying out these experiments was the same as that followed in 1951. Twenty cutworms approximately half grown or slightly larger were placed in each of the eighteen tins for each replicate. Thirty freshly gathered alfalfa leaflets were fed to each lot of cutworms daily throughout the course of each experiment. Each bait was made up of 25 grams bran and 25 c.c. water and the amount of poison required to provide the ratios of poison and dry bran stated above. The required amount of each poison was mixed with the 25 c.c. of water and this was then added to the dry bran in an Atlas cardboard container and all shaken together thoroughly until every particle of the bran was damp. In each experiment approximately one level teaspoonful, approximately 1.8 gms., of the prepared bait was scattered over the bottom of each tin which had an area of approximately 82.5 square inches. Each cutworm larva could choose between fresh alfalfa leaflets or bran in each tin. Counts of dead, dying and active cutworms were made 24, 48 and 72 hours after each bait had been given. In these experiments 1440 cutworm larvae were used.

**RESULTS AND DISCUSSION.**—The results of this investigation are shown in Table 1. Each experiment was replicated four times. For example, in Experiment 1 the bait containing one part aldrin to 166 parts dry bran was fed to four different lots of 20 cutworms and the average percentage of dead cutworms among the 80 specimens was 7.6 at the end of 24 hours. An examination of the data in Table 1 shows that isodrin acts slightly more quickly than the other insecticides on cutworm larvae. If 95 per cent effectiveness is used as an arbitrary criterion, Table 1 shows that one part of aldrin, endrin or isodrin to 666 parts of dry bran is sufficient to effect a satisfactory cutworm mortality. To obtain similar results one part of dieldrin to 333 parts of bran must be used. One part toxicant to 666 parts of dry bran means that 2.4 ounces of aldrin, endrin or isodrin mixed with 100 pounds of dry bran and an equal weight of water will give effective cutworm control if these laboratory results are applicable to field control. Approximately five ounces of dieldrin should give equally effective results. Experimental work not reported at this time indicates that cutworms may be killed by coming in contact with these poisons in the bait.

**SUMMARY.**—(1) Aldrin, endrin and isodrin when used at the rate of one part actual chemical to 666 parts dry bran gave laboratory control of cutworms at or above the 95 per cent mortality level.

(2) Dieldrin gave similar control when used at the rate of one part chemical to 333 parts dry bran.

**ACKNOWLEDGMENTS.**—Financial assistance for this project was received on an equal basis from Julius Hyman and Company, Denver, Colorado and Shell Chemical Corporation, New York City. The aldrin, sample 9561; dieldrin, sample 9562; endrin (compound 269), sample 9563; and isodrin (compound 711), sample 9564 were supplied by Julius Hyman and



Table 1  
THE LETHAL EFFECTS OF ALDRIN, DIELDRIN, ENDRIN AND ISODRIN  
WHEN USED AT FOUR CONCENTRATIONS IN A BRAN-WATER BAIT ON CUTWORM LARVAE

Insecticide	Experiment	Ratio of insect- icide to bran	24 hours after baiting				48 hours after baiting				72 hours after baiting			
			% dead	% dying	% active	% dead and dying	% dead	% dying	% active	% dead and dying	% dead	% dying	% active	% dead and dying
aldrin	1	1-166	7.6	84.8	7.6	92.4	39.2	60.8	0.0	100.0	84.8	15.2	0.0	100.0
aldrin	2	1-333	8.7	78.8	12.5	87.5	41.8	55.7	2.5	97.5	78.7	20.0	1.3	98.7
aldrin	3	1-666	10.0	61.2	28.8	71.2	30.0	63.8	6.2	93.8	70.0	26.2	3.8	96.2
aldrin	4	1-1333	5.0	57.5	37.5	62.5	29.6	46.9	23.5	76.5	49.4	37.0	13.6	86.4
dieldrin	5	1-166	8.8	65.8	25.4	74.6	18.9	74.7	6.4	93.6	78.5	21.5	0.0	100.0
dieldrin	6	1-333	3.7	53.8	42.5	57.5	27.5	55.0	17.5	82.5	47.5	47.5	5.0	95.0
dieldrin	7	1-666	2.5	49.4	48.1	51.9	11.2	73.8	15.0	85.0	29.1	55.7	15.2	84.8
dieldrin	8	1-1333	1.3	55.7	43.0	57.0	26.9	37.2	35.9	61.1	38.9	28.6	32.5	67.5
endrln	9	1-166	3.8	91.1	5.1	94.9	51.9	48.1	0.0	100.0	93.7	6.3	0.0	100.0
endrln	10	1-333	7.5	76.2	16.3	83.7	41.2	56.3	2.5	97.5	88.3	10.4	1.3	98.7
endrln	11	1-666	19.0	62.0	19.0	81.0	52.5	40.0	7.5	92.5	82.5	12.5	5.0	95.0
endrln	12	1-1333	9.1	62.3	28.6	71.4	44.3	45.6	10.1	89.9	85.7	9.1	5.2	94.8
isodrin	13	1-166	10.0	87.5	2.5	97.5	45.0	55.0	0.0	100.0	92.5	7.5	0.0	100.0
isodrin	14	1-333	18.7	81.3	0.0	100.0	66.2	33.8	0.0	100.0	95.0	5.0	0.0	100.0
isodrin	15	1-666	8.7	78.8	12.5	87.5	55.0	43.8	1.2	98.8	83.7	15.0	1.3	98.7
isodrin	16	1-1333	18.7	60.0	21.3	78.7	51.2	42.5	6.3	93.7	85.0	8.7	6.3	93.7
check	17		0.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	1.4	98.6	1.4
check	18		0.0	0.0	100.0	0.0	0.0	1.3	98.7	1.3	2.7	2.7	94.6	5.4

NOTE: Each experiment was replicated four times with 20 cutworms in each replicate. The results are averages of the four replicates for each experiment.

Company. Messrs. B. Furgala and A. L. Chiykowski, student assistants, collected and sorted the larvae used in these experiments. This assistance which is much appreciated has made it possible to complete this investigation.

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### CUTWORM CONTROL WITH GROUND SPRAYS IN MANITOBA IN 1952

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A very heavy and extended outbreak of cutworms (Phalaenidae) occurred in the Red River Valley in Manitoba in 1952. It is believed that the red-backed cutworm, *Euxoa ochrogaster* (Guen.), was the dominant species although no doubt other species also were involved. Sugar beet growers were among those most concerned although general farmers reported damage to fields of barley, flax, oats, peas, sunflowers and wheat. Market gardeners also had crops of beans, cabbage, cucumber, onions and tomatoes as well as flowers under attack. Altogether this was probably the most severe outbreak of cutworms in Manitoba in the last 30 years or more.

The use of poisoned baits had been the only control recommended in Manitoba for cutworms previous to 1952. Many farmers now own large sprayers which for a number of years have been used to control farm weeds. It was decided to undertake experimental control of cutworms with ground sprays in 1952. The Manitoba Sugar Co. Ltd. has many farmers under contract to grow sugar beets. Field supervisors are in direct contact with these growers throughout the season. Through its head office, farmers were advised to use 3.6 ounces of actual dieldrin or 32.0 ounces of actual toxaphene per acre. Each insecticide was used in an emulsifiable formulation. Different types of sprayers deliver varying gallonages per acre and each farmer was advised to use the designated amount of toxicant in the amount of water that his sprayer would apply per acre. Farmers were told that this method of control was experimental as far as we were concerned in Manitoba. The ground spraying method of cutworm control met with the approval of many farmers at the outset as they could treat large fields quickly and with much less work than was involved in preparing and applying poisoned baits. At our request a list of farmers using ground sprays for cutworm control was compiled by the Manitoba Sugar Co. Ltd. A questionnaire was prepared and sent by the Department of Entomology to 191 farmers who had used these ground sprays. This report on the results of this experiment is based upon 49 completed forms which were returned. It is estimated that well over 6000 acres of various crops were sprayed for cutworm control in Manitoba in 1952.

DISCUSSION.—Most farmers who used the experimental emulsifiable formulation of dieldrin applied it at the rate of one gallon, containing 1.8 pounds of actual toxicant per gallon, to eight acres which was the recommended dosage of 3.6 oz. per acre. Some farmers used slightly less and a few used somewhat more. Table 1 shows that the average dosage for 21 farmers reporting was 3.6 oz. per acre. Farmers were asked to estimate the percentage of cutworms killed. Estimates varied from 75 to 100 per cent and averaged 91.2 per cent. Fifteen of the 21 farmers estimated a control of 90 per cent or more. Comments made by farmers indicated that they were well satisfied with the control obtained. One farmer said, "The control is easily applied and very effective.". Another farmer stated, "I also found cutworms dying from its effects a week after spraying and a rain fell two days after spraying." "Dieldrin is very effective and satisfactory,"

said another sugar beet grower. It is significant that every farmer who reported, considered the application effective. Some farmers felt that it was a dangerous chemical to use. Great care must be taken in handling this as well as all other insecticides.

The recommended dosage of toxaphene was 32.0 ounces of actual toxicant per acre. The commercial emulsifiable formulation used contained six pounds of actual toxicant per gallon and the recommended dosage was one gallon of toxaphene in sufficient water to spray three acres.

Table 1

## DIELDRIN AND TOXAPHENE IN GROUND SPRAYS FOR CUTWORM CONTROL

Toxicant Used	Number of Farmers Replying to Questionnaire	Crop	No. Acres Sprayed	Average Amount Actual Toxicant Used Per Acre	Number Farmers Reporting Results Effective	Average Estimated Percentage Control	Number Farmers Reporting Results Unsatisfactory
dieldrin	21	sugar beets	463	3.6 oz.	21	91.2	0
toxaphene	23	sugar beets	977	33.8 oz.	18	86.7	3
toxaphene	5	flax, oats, peas	90	34.0 oz.	5	96.0	0

One farmer used as little as 20.0 ounces per acre and another used 72.0 ounces per acre, but the majority used approximately the amount recommended. The average as shown in Table 1 was 33.8 ounces per acre for sugar beets and 34.0 ounces per acre for grain crops. The average estimated control was 88.3 per cent. Three farmers out of 23 reporting on results from spraying sugar beet ground were not satisfied with the results but each of these farmers had used only 24.0 ounces per acre. The other 20 farmers thought that the control was effective.

**RECOMMENDATIONS.**—Sprays should be applied in the evening or as late in the day as possible. The application should be made on a calm warm day when there is the prospect of a warm night when cutworms will be most active. The ground should be covered evenly with the spray and at least five gallons of water should be used per acre. The emulsifiable formulation of an insecticide is recommended.

Great care must be taken in handling these poisons. Do not allow the spray to come in contact with exposed parts of the body or with clothing. Avoid having the spray drift in the direction of the operator. Do not blow out clogged nozzles with the mouth. If any of the insecticide is spilled on clothing remove that clothing and put on clean garments at once. Wash hands and face and soiled clothing with soap and water to remove any adhering poison. Keep all containers of poison away from children and live stock. Keep the chemicals stored away from frost.

**SUMMARY.**—Dieldrin when used at the rate of 3.6 ounces of actual toxicant per acre and toxaphene when used at the rate of 32.0 ounces of actual toxicant per acre each gave very satisfactory control of cutworms when used in water as a ground spray in Manitoba in 1952. Farmers preferred ground spraying to ground baiting as the former is quicker, easier to accomplish and very effective. In most cases only one application is needed if it is applied when the cutworm damage is first noticed and when optimum weather conditions prevail.

**ACKNOWLEDGMENTS.**—The writer wishes to acknowledge the assistance of Mr. E. G. Minielly, Manitoba Sugar Co. Ltd. and his field supervisors for their ready co-operation. He is also grateful to the Manitoba Department of Agriculture for making the dieldrin available. The assistance of many farmers in completing and returning questionnaires is also much appreciated.



NOTES ON *STETHORUS PUNCTUM* (LEC.)  
(COLEOPTERA: COCCINELLIDAE),  
A PREDATOR OF TETRANYCHID MITES IN MANITOBA<sup>1</sup>

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During 1950 and 1951 a study was made at Brandon to determine the predators of tetranychid mites, particularly those of *Eotetranychus mcdanieli* (McG.) and *Eotetranychus pacificus* (McG.), present in Manitoba (Robinson, 1952). The most abundant, and possibly the most important, predator found was a small, black ladybird beetle, *Stethorus punctum* (Lec.). Although *S. punctum* has been frequently mentioned in the literature on predators of mites, very little detailed information on its biology is available. Some earlier papers giving information on the biology of *S. punctum* are those of Duffey (1891), Weldon (1909), McGregor and McDonough (1917), and Garman and Townsend (1938). The following notes supply additional information on the habits of this valuable predator.

All stages of *S. punctum* are found on the lower surfaces of leaves infested with mites. Both adults and larvae are predacious on all stages of the host mites.

*S. punctum* overwinters as an adult, hibernating in trash cover under trees or shrubs, under bark, or in other protected habitats. Winter mortality in Manitoba is apparently high, for adults are abundant in late autumn but scarce in the spring. Adults were found on leaves from May 21 to September 22 in 1951.

There are at least two complete generations per year in Manitoba. They overlap so much that overwintered, first-, and second-generation adults may be found at the same time on one tree later in the season. In the laboratory, with constant optimum temperatures, suitable humidity, and plenty of food for the adults and larvae, four generations could be reared in one season.

#### ADULT

Adults are capable of a quick, jerky flight and can fly at least a few yards. Often, when disturbed on a leaf in the field they drop to the ground to escape.

Laboratory studies showed that a segregated pair may mate more than once. The time spent in copula varies from a few seconds to two or three hours. Males often attempt to mate with other males, and the only positive means of determining sex is by dissection. Adult females occasionally lay infertile eggs if no mating has been allowed.

#### EGG

The eggs are laid singly, normally one on a leaf, but if the mite population is large there may be two or three. They are usually found close to a leaf vein, often underneath the webbing made by the mites, and sometimes partly hidden under mite exuviae or miscellaneous debris on the leaf. The eggs adhere tightly to the lower surface of the leaf, as though the egg chorion had been sticky when laid and had hardened immediately. In laboratory rearing, with only one leaf available to a female for a 24-hour period, normally four to ten eggs per leaf were found, with a maximum of 24.

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The egg is pearly white for about half the incubation period, and then very gradually darkens. Two small, pink eye-spots appear at one end of the egg. About 36 hours before the larva is due to emerge, the whole egg turns greyish-black. The chorion splits lengthwise down both sides, from one end, for about half the total length, and the larva emerges head first.

*Effect of temperature on incubation:* Eggs of *S. punctum* were kept at various constant temperatures to determine the effect of temperature on incubation. A suitable humidity was maintained by moistening daily the cotton plug in the glass vial in which the leaf and eggs were placed.

The eggs can withstand low temperatures of 40 to 50°F. for a few days. However, prolonged exposure to cold, even at 55°F., will eventually destroy the embryos.

The temperature range for incubation of the eggs apparently lies somewhere between 55 and 110°F. (Table 1). The table also shows that embryological development is progressively delayed by lower temperatures. A temperature of 80°F. may be taken as the optimum; this is closer to the maximum than to the minimum.

Table I

EFFECT OF TEMPERATURE ON INCUBATION PERIOD OF *STETHORUS PUNCTUM*

Temperature °F.	No. of eggs	Per cent mortality	Incubat. period in days Range	Mean
110	56	100	—	—
100	55	5.5	3	3
90	58	1.7	3-5	3.4
80	55	0	3-6	4.1
75	59	3.4	3-6	4.3
70	81	18.5	6-9	7.4
65	67	28.4	7-12	9.9
60	77	27.3	10-17	13.6
55	36	100	—	—

## LARVA

Larvae of *S. punctum* are voracious feeders. They alternately drain out and regurgitate into the body the fluid contents of the host mite. This process is repeated several times before the contents of the prey are permanently removed.

When a larva is searching for food, it apparently does not perceive the presence of the prey until physical contact has been made.

Occasionally when the larvae are molested they excrete two small droplets of fluid from glands apparently on the dorsal side of the abdomen, near the thorax. The exact location of these glands was not determined. The excretion of these droplets was particularly noticeable when larvae were being anaesthetized for photography.

Whenever several larvae were placed in one small vial in the laboratory, their numbers were reduced to one or two individuals by cannibalism. A larger larva would readily seize and devour a smaller one encountered during the search for mites. Under natural conditions cannibalism is probably not frequent, because there is usually only one larva on a leaf.

There are four larval instars. Of 43 larvae reared to pupae at 80°F., the average durations of the instars were: first, 2.1 days; second, 1.4 days; third, 1.4 days; and fourth, 2.5 days; the average total was 7.4 days. Observations indicated that in the field the larval period ranges from 12 to 30 days, depending on weather and food supply.

#### PUPA

The fourth-instar larva attaches itself to the underside of a leaf by the anal end and remains without feeding or locomotory movement in this prepupal condition for 24 to 48 hours before pupation. The larval skin is shed and worked down to the anal end of the abdomen, where it remains. The pupa is at first very light brown, or yellowish, and turns black in about four hours. The emerging adult is very light brown, or yellowish, but turns black in about four hours. The old pupal skin remains attached to the leaf after the adult has emerged.

The duration of the pupal stage of 101 pupae at 80°F. averaged 3.0 days.

#### EFFECT OF DDT AND METHOXYCHLOR ON ADULTS

A laboratory test was conducted to determine the effects of DDT and methoxychlor on adults of *S. punctum*. Leaves were dipped in solutions of wettable powders of DDT or methoxychlor containing 0.5 lb. of technical toxicant per 100 gal. of water. The beetles were exposed to treated leaves for two hours. Of 70 beetles subjected to the leaves treated with DDT, 33 died. Of 70 beetles subjected to the leaves treated with methoxychlor, 42 died. There was no mortality in 70 beetles placed on leaves dipped in water only. The two insecticides are apparently equally toxic under the conditions of this test.

#### SUMMARY

*Stethorus punctum* (Lec.) is an important and abundant predator of tetranychid mites in Manitoba.

Some notes are given on life-history and habits of the various stages.

Eggs hatch at temperatures from 60 to 100°F., with an optimum at 80°F., and hatching is progressively delayed by lower temperatures.

Adults exposed for two hours to leaves treated with either DDT or methoxychlor at 0.5 lb. of technical toxicant per 100 gal. of water suffered about 50 per cent mortality.

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PROGRESS REPORT ON PREDACIOUS MITE INVESTIGATIONS  
IN NOVA SCOTIA (ACARINA: PHYTOSEIIDAE)<sup>1</sup>H. J. HERBERT<sup>2</sup>*Fruit Insect Section, Science Service Laboratory, Kentville, Nova Scotia*

## INTRODUCTION

In recent years phytophagous mites have become important pests of fruit trees. This change in status from minor to major pests is evidently associated with the destructive action of certain sprays on their predators. Included in the latter category is an important group of predacious mites belonging to the subfamily Phytoseiinae (Phytoseiidae).

In Nova Scotia the European red mite, *Metatetranychus ulmi* (Koch), is the most destructive phytophagous mite and studies have been undertaken to determine the interrelations existing between it and the predacious mites.

Field studies by Lord (1949) have shown that when the phytoseiids and other predators are destroyed by the use of certain spray chemicals, the red mite populations increased rapidly. When spraying is discontinued or chemicals harmless to the predacious species are used, the phytoseiids, as well as other predators, increase rapidly to the point where a host-predator equilibrium is restored. Phytoseiids appear to be the most important factor in the maintenance of low host densities (MacPhee, 1953). Exploratory studies and observations suggest a similar relationship between phytoseiids and other phytophagous mite species.

Because of the important role played by phytoseiids in the control of phytophagous mites, studies have been undertaken of the life-histories, behaviour, distribution, and relative abundance of these predators.

In the literature before 1948, phytoseiids found on apple trees were usually grouped together under the name of *Seiulus pomi* Parrott. Garman (1948) began to unravel this tangle by describing a number of the species formerly confused under the name of *S. pomi*. Nesbitt (1951) continued this and compiled the results of studies on phytoseiids. He transferred the species described by Garman in the genus *Iphidulus* to the genus *Typhlodromus*.

The following species have been found on apple trees in Nova Scotia, namely: *Typhlodromus tiliae* Audms., *T. conspicuus* (Garm.), *T. conspicuus* var. *herbertae* Nes., *T. masseei* Nes., *T. cucumeris* Oudms., *T. fallacis* (Garm.), *T. longipilus* Nes., *T. finlandicus* Oudms., *T. pomi* (Parrott) Garm., *T. (Neoseiulus) rhenanus* Oudms., *T. (N.) bakeri* (Garm.), *T. tiliarum* (Garm.), *Phytoseius macropilis* (Banks), and *Amblyseius* spp.

## METHODS

*Field Studies.*—Field work was confined mainly to the study of habits and relative abundance. One leaf cluster was taken at random from each of ten trees in the observational orchards at weekly intervals throughout the growing season.

Counts were made of the stages of phytoseiids present and the adults were removed for later mounting and identifications with a compound microscope. As the eggs, larvae, and nymphs of the various species are indistinguishable, this naturally limits the number of observations and the type of field studies that can be made.

<sup>1</sup>Contribution No. 3093, Division of Entomology, Science Service, Department of Agriculture, Ottawa, Canada; presented at the annual meeting of the Entomological Society of Canada, Quebec, on October 30, 1952.

<sup>2</sup>Agricultural Research Officer.

*Laboratory Studies.*—Phytoseiid mites are very difficult to handle because of their small size and rapid movements. Attempts were made to rear the mites in felt cells on apple leaves; in small glass vials with the food supplied on a piece of leaf; and in gelatin capsules fastened to a piece of cardboard, the food supplied on a piece of leaf (Bare, 1942). These methods proved unsatisfactory. A no. 2 pharmaceutical capsule bearing the food in the short portion or cap was the most satisfactory rearing chamber. *Tetranychus* spp. eggs were used as food as they were easily obtained and transferred relatively easily. When the mites were to be fed, they were induced to move into the long portion of the capsule so that the cap might be removed and replaced by one containing food. These capsules were placed in a jar containing a saturated solution of ammonium chloride to maintain a constant degree of humidity.

As it was necessary to rear the progeny from parents whose identities had been determined, the studies were limited to laboratory conditions. A field check of the development of individual species of phytoseiids is virtually impossible in Nova Scotia orchards since phytoseiid populations are made up of more than one species.

### RESULTS

*Field Studies.*—The number of species and the relative numbers of each vary from orchard to orchard and from year to year. The figures shown in Table I are percentages based on weekly collections in each orchard throughout the season.

Table I

#### SPECIES OF PHYTOSEIIDS IN SIX ORCHARDS: PERCENTAGES OF TOTAL

Species	Orchard Number											
	1		2		3		4		5		6	
	1950	1951	1950	1951	1950	1951	1950	1951	1950	1951	1950	1951
<i>Typhlodromus tiliae</i>	3	1	0	0	0	0	91	99	89	87	24	91
<i>T. (Neoseiulus) rhenanus</i>	47	20	2	3	10	0	8	0	1	0	0	0
<i>T. pomi</i>	32	49	0	2	8	18	0	0	0	1	0	0
<i>T. fallacis</i>	0	1	0	0	0	0	1	0	3	0	76	9
<i>T. conspicuus</i> var. <i>herbertae</i>	8	29	1	1	47	54	0	0	5	0	0	0
<i>T. finlandicus</i>	3	0	0	0	0	0	0	0	1	12	0	0
<i>T. masseei</i>	0	0	0	0	0	0	0	1	0	0	0	0
<i>Phytoseius macropilis</i>	7	0	96	94	35	28	0	0	1	0	0	0
<i>Amblyseius</i> spp.	0	0	1	0	0	0	0	0	0	0	0	0

Populations of phytoseiids were denser in the centres of the trees in the spring and early summer. At the peripheries they increased in midsummer and then, as autumn approached, they decreased (Fig. 1).

Overwintering adult females are commonly found in the calyx cups of the apples in the autumn. They spend the winter under bark scales of the larger branches and tree trunks, in empty hibernacula of the eye-spotted bud moth, in empty oystershell scales, or in codling moth cocoons.

Phytoseiid females have been seen crawling on the bark scales during the warmer days of late winter and early spring, and have been found running about on the green buds by the middle of May. Egg laying commences about the end of May. As yet, no males of any species have been found overwintering.



Fig. 1. Population trend of phytoseiids on peripheral leaf clusters for 1951.

*Laboratory Studies.*—So far, laboratory studies have been largely confined to the species *T. fallacis* Garm. Six generations were reared at a temperature of  $70 (\pm 2)^{\circ}\text{F.}$  and a relative humidity of about 79 per cent. Eggs of the first generation were deposited by an overwintering female.

The incubation period lasted 3 to 4 days, the nymphal period about 1 day, and the larval period 3 to 4 days. The total time from hatching to adult was from 5 to 6 days, and the pre-oviposition period 7 to 8 days.

The longevity recorded for the females was 30 to 65 days, and for the males 10 to 24 days. On the average, a total of 37.5 eggs, or 2.7 eggs per day, were laid.

The female is fertilized in the adult stage; one male may fertilize more than one female. As yet, parthenogenetic development has not been observed.

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CYTOCHROME OXIDASE AND CYANIDE SENSITIVITY OF THE LARCH SAWFLY DURING METAMORPHOSIS<sup>1</sup>

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## INTRODUCTION

The early work of Bodine (1934) demonstrated that the embryo of the grasshopper, *Melanoplus differentialis* (Thos.), when in winter diapause was insensitive to solutions of potassium cyanide, ranging from 0.02 to 0.05 per cent, which markedly depressed the respiratory rate of such embryos during pre- and post-diapause development. Moreover, he found that the fraction of the developing respiratory rate which remained resistant to cyanide was roughly equivalent to the entire diapause respiration, which was completely resistant to cyanide poisoning at these levels of concentration.

More recently Williams (1947) discovered that the diapause pupa of the silkworm, *Platysamia cecropia* (L.), is similarly insensitive to levels of cyanide that largely inhibit the respiratory rate of the caterpillars before pupation or of the adults after emergence. Sanborn and Williams (1950) proceeded to demonstrate that the diapause respiration may be ascribed to the flavoprotein system of cellular oxidative enzymes, while the respiration, which is superimposed upon it when development resumes, is performed by the cytochrome system of co-enzymes and the enzyme cytochrome oxidase. They found that cytochrome oxidase decreases to a low level at pupation and is rapidly resynthesized shortly after the pupal diapause has ceased. Very recently however, Sacktor (1951) has shown that cytochrome oxidase decreases to much the same extent in the non-diapause pupa of the house fly, *Musca domestica* (L.), and is rapidly resynthesized during the histogenesis of the adult.

## MATERIAL AND METHODS

The experiments reported in this paper were performed on the larch sawfly, *Pristiphora erichsonii* (Htg.), in which the diapause stage occurs in a larval form known as the conymph, and the pupal stage follows the resumption of development. The material was collected from northwestern Ontario as conymphs in cocoons, and was stored at 2°C in a refrigerator during the winter diapause period; they were removed in March, when they resumed development as pronymphs, became pupae and reached the adult stage in 35 days.

Measurements of the respiratory rate were made using the Warburg constant-volume manometric method (Umbreit *et al* 1949) on the pre-diapause, diapause and post-diapause stages. The determinations of the cytochrome oxidase content were made on the diapause and post-diapause stages using the manometric method of Schneider and Potter (1943).

Cyanide sensitivity was assessed by the simple method originally followed by Bodine (1934) of immersing the insect material in dilute solutions of potassium cyanide in distilled water for three hours. The pH of such solutions ranged between 10 and 11, resulting in free dissociation of the cyanide ions. The insects were removed and dried and their respiratory rate was measured immediately, again 13 hours later and finally seven days after treatment. Since this simple method did not remove the factor, possibly variable, of cuticular penetration, the assessments were repeated with insects which had been split open. McIlvaine's phosphate buffer (Clark, 1923) was used as the solvent of the potassium cyanide, and the pH ranged from 6.8 for dilute to 9.2 for the more concentrated solutions of cyanide. Finally, assessments were made of the cyanide sensitivity of insect tissues homogenized in distilled water and suspended in the solutions of KCN in phosphate buffer within the Warburg apparatus.

<sup>1</sup>This investigation was financially assisted by a grant-in-aid from the National Research Council of Canada.

## RESULTS

The respiratory rate of the eonymphs was found to remain at a low level throughout diapause (Table 1), even after the eonymphs had been removed from the refrigerator. Once development had resumed, some three weeks after the return to room temperature, the respiratory rate increased rapidly and this increase was not interrupted during the pupal stage.

The cytochrome oxidase content (Table 1) showed a parallel increase to that of the respiratory rate, but of much more modest proportions and was interrupted by a slight but significant set-back during the pupal period.

Table 1

RESPIRATORY RATE AND CYTOCHROME OXIDASE CONTENT OF LARCH SAWFLY BEFORE, DURING AND AFTER METAMORPHOSIS.

	<i>Oxygen consumption</i> <i>cu. mm./gm. wet wt./hr.</i>	<i>Cytochrome oxidase</i> <i>cu. mm./mg. dry wt./hr.</i>
Larvae		
Just cocooned, Aug. 15	not determined	1.13
Eonymphs		
Refrigerated Sept. 18 to March 19	165	1.33
Eonymphs		
Apr. 22, 20 days after refrigeration	165	1.45
Pronymphs		
23 days after refrigeration	270	2.05
White Pupae		
28 days after refrigeration	376	1.82
Dark Pupae		
35 days after refrigeration	969	2.91
Adults (immobile)		
35 days after refrigeration	1155	not determined

The respiration of diapause eonymphs was found to be unaffected by concentrations of cyanide up to 0.02 per cent (Fig. 1), partially and reversibly inhibited by concentrations up to 0.5 per cent and completely and irreversibly inhibited by concentrations of 1 per cent potassium cyanide. The respiration of developing white pupae was reversibly inhibited by concentrations of 0.02 to 0.25 per cent potassium cyanide. Their level of sensitivity, as indicated in the proportion of respiration that was inhibited, is therefore only slightly greater than that of the diapause eonymphs.

When the diapause eonymphs, with their cuticles split, were exposed to cyanide solutions (Table 2), their respiration was found to be considerably reduced by concentrations which had little effect on the intact insects. The act of splitting the insects did not materially change their respiratory rate if they were suspended in buffer without cyanide.

Control assessments of tissue homogenates without KCN show that the tissues consume oxygen at a considerably lower rate than the intact insects. When tissues of diapause eonymphs and developing pupae are compared (Table 2) they both show partial inhibition by cyanide to a similar extent.

Figure 1: The Effect of KCN on Diapause and Post-diapause Respiration.

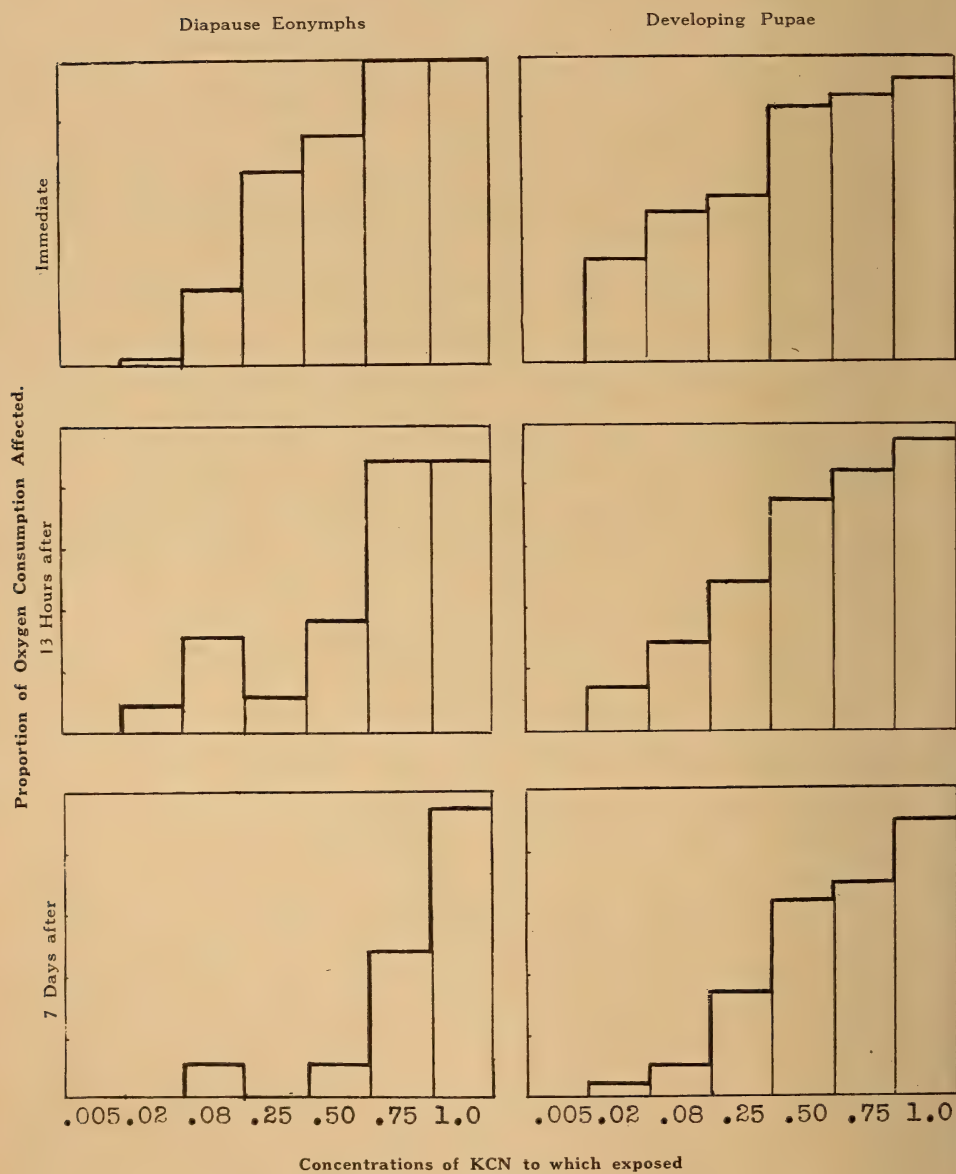




Table 2.

## EFFECT OF POTASSIUM CYANIDE ON EONYMPHS AND WHITE PUPAE OF THE LARCH SAWFLY, AND ON THEIR TISSUES.

	<i>Eonymphs</i>			<i>White Pupae</i>	
	<i>Intact</i>	<i>Split</i>	<i>Homogenized</i>	<i>Intact</i>	<i>Homogenized</i>
Respiratory rate, in cu. mm./gm./hr. of larch sawfly material.					
	170	142	78	450	47
per cent KCN	percentage reduction in respiratory rate immediately after KCN treatment.				
0.005	0	46	49	0	28
0.02	9	80	67	31	53
0.08	29	89	77	48	79

## DISCUSSION

These results obtained with larch sawfly during diapause and later metamorphosis do not show the clear-cut contrasts obtained by Bodine with grasshopper embryos, and by Williams with cecropia pupae. Although 0.02 per cent KCN caused a reversible inhibition of respiration in developing pupae of the larch sawfly, concentrations of 0.5 per cent KCN were required to effect a marked but reversible inhibition; whereas Bodine found that 0.02 per cent KCN was sufficient to temporarily reduce the respiration of the developing embryos of *Melanoplus differentialis* to a low level. Also in contrast to the clear-cut results of Bodine, it is found with the larch sawfly that dosages which are reversibly inhibitory for developing pupae, temporarily inhibit the diapause eonymphs to almost the same extent. But the upper range of these dosages is so high that the inhibition is not restricted to cytochrome oxidase but involves a more generalized effect.

There is evidently no significant decrease in cytochrome oxidase activity when the cocooning larva becomes a diapause eonymph. In the cecropia silkworm studied by Williams the diapause stage is a pupa, in which the process of histolysis occurs, and it is here that the cytochrome oxidase falls to a low level. In the larch sawfly the pupa is a stage interposed during the resumption of development, and here it was found that the cytochrome oxidase level was slightly but significantly reduced, before resuming its increase during later pupal life.

## CONCLUSIONS

The diapause stage of the larch sawfly, which is the eonymph or final larval instar, does not experience a significant decrease in cytochrome oxidase content. The resumption of development after diapause is paralleled by an increase in cytochrome oxidase content, which experiences a slight set-back during the early part of the short pupal stage.

The oxygen consumption of diapause eonymphs is not significantly less sensitive to cyanide poisoning than that of post-diapause pupae. Comparatively high levels of cyanide are required to inhibit the respiration of the intact individuals of both stages, although the sensitivity of each is correspondingly increased by direct exposure of their tissues to the cyanide solutions.

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## DIPTERA AND HYMENOPTERA REARED FROM PINE CONE WILLOW GALLS CAUSED BY *RHABDOPHAGA STROBILOIDES* (DIPTERA : ITONIDIDAE)

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During March of 1951 two hundred and fifty Pine Cone Willow galls were removed from shrubs of willow, *Salix* sp., in a small swamp on Highbury Avenue in London Township, two miles north of the city limits of London, Ontario. This gall is caused by the fly *Rhabdophaga strobiloides* Walsh and commonly harbors inquiline flies of the genus *Dasyneura*. Rearing of the insects in the galls was undertaken to disclose what flies occurred in them and to discover what insects parasitized these flies and, where possible, the exact hosts of the various parasitic species. In a preliminary investigation several galls were collected and brought into the laboratory. Each one was dissected by removing the scales, in sequence from the lowest outer scales to the inner scales of the core, and the contents of the gall were noted as dissection proceeded. The core of a gall (Figs. 1,5) consisted of stiff, upright, elongated scales and in the cavity between the bases of these scales was an itonidid larva (Fig. 1), slightly less than one-quarter inch in length, standing vertically among the scales. Between the outer rounded scales of the galls a variety of specimens were found: small itonidid cocoons about 2 mm. long (Fig. 3B) closely appressed to the scales, small yellow hymenopterous larvae and the elongated yellowish eggs of a long-horned grasshopper (Tettigoniidae) (Fig. 3A).

### METHODS OF REARING

The two hundred and fifty galls from which insects were to be reared were collected in three lots:

Lot 1. On March 3, one hundred and fifty galls were collected and prepared for the rearing of insects from them. Each gall was placed in a small cotton-plugged jar, the jars being numbered from 1 to 150 and kept on a rack. Each day the jars were examined for the presence of emerged insects which were removed with an aspirator and pinned and labelled.

Lot 2 On March 10, fifty galls were collected and used to investigate what insects occurred in the cores. The outer scales were stripped off, leaving only the central core of a gall attached to its base (Fig. 5). Each of the fifty cores was placed in a cotton-plugged vial of dimensions 40 mm. by 8 mm. The vials, numbered from 151 to 200, were examined daily and emerged insects were collected from them.

Lot 3. On March 31, fifty galls were collected and used to investigate what insects occurred among the outer rounded scales of the galls. From each gall the scales were stripped off and the insects found between them were kept, the cores being discarded. Three groups of specimens were extracted from between the scales of these fifty galls:

A. Eighty-six eggs of a long-horned grasshopper were removed from eleven galls and were placed in a few cotton-plugged vials of dimensions 40 mm. by 8 mm.

B. Twenty-eight small, yellow hymenopterous larvae were found and were reared in vials.

C. One hundred and forty small, white itonidid cocoons were placed in vials for the rearing of their contents.

The collection and pinning of emerging insects was continued daily until June 15 – 18 when the galls and cores numbered 1 to 200 (Lots 1 and 2) were dissected and all remaining insects in them were removed and pinned or preserved in fluid. Remaining material from Lot 3 (A, B, C) was also discarded. The specimens were sorted out and representative specimens were kindly identified by specialists in the classification of the various taxonomic groups at the United States National Museum. Dr. R. H. Foote identified the flies of the family Itonididae, Dr. C. F. W. Muesebeck identified wasps of the families Braconidae, Platygasteridae and Ceraphronidae, Dr. B. D. Burks identified the chalcidoid wasps and a tenthredinid sawfly and Dr. L. H. Weld identified a wasp of the family Cynipidae. Several specimens were retained for the collections of the United States National Museum, as will be noted later in the discussion of the species involved. Dr. O. Peck, Systematic Entomology, Department of Agriculture, Ottawa, examined some of the chalcidoid wasps and retained some specimens for the Canadian National Collection. All other specimens are in the insect collection of the University of Western Ontario.

The results of the rearing are presented in Table 1 (Lot 1), Table 2 (Lot 2), Table 3 (Lot 3B), Table 4 (Lot 3C) and Table 5 (Summary of all emergents).

## ACCOUNT OF SPECIES REARED

### DIPTERA

#### ITONIDIDAE

##### *Rhabdophaga strobiloides* Walsh

Adults of this fly, which causes the gall, emerged first on March 23 from complete galls, twenty days after the galls were brought into the laboratory. Only six adults succeeded in emerging from the complete galls (Table 1), and twenty from the cores (Table 2). After all the galls were dissected on June 18 many were found to contain in their cores the shrivelled pupae of *R. strobiloides* from which the adults had failed to emerge. When the galls were brought into the laboratory during March the insects were still in the larval state (Fig. 1) and when the pupal state was completed the pupa moved to the tip of the gall and the adult emerged, leaving the empty pupal skin projecting from the tip of the gall (Fig. 2). Three male and three female specimens are deposited in the United States National Museum.

##### *Dasyneura (albovittata) Walsh?*

The cocoons of this fly were lodged between the outer scales of the gall (Fig. 3B) and when an adult emerged from the end of a cocoon it left the pupal skin projecting from the tattered end of the cocoon (Fig. 4). Adults first emerged from the complete galls on March 31 (Table 1) and they appeared from only 17 of these galls. After the complete galls were dissected on June 18 many *Dasyneura* cocoons were found between the scales, varying in number from one to fifteen per gall. The flies also emerged in considerable numbers from the cocoons in Lot 3C (Table 4). Three male and three female pinned specimens are deposited in the United States National Museum.



## HYMENOPTERA

## TENTHREDINIDAE

*Amauronematus* sp.

A single female sawfly emerged on March 17 (Table 1) from a cocoon lodged beneath one of the lower scales of a gall (Fig. 6). Ross (1951) lists several species of this genus as feeders on willow and it is likely that the cocoon spun on the gall was made by a larva which had been feeding on the foliage of the willow.

## BRACONIDAE

*Diaeretus salicaphis* (Fitch)

Seven wasps emerged from six complete galls, the first on March 17 (Table 1). Muesebeck and Walkley (1951a) list a number of aphids as hosts of *D. salicaphis* and related species and state that all species in the subfamily Aphidiinae are internal parasites of aphids. Since *D. salicaphis* emerged from complete galls the specific host of the wasps cannot be exactly determined. It is possible that they emerged from aphids clinging to the scales of the galls. One female specimen is deposited in the United States National Museum.

*Aphidius phorodontis* Ashm.

One wasp emerged from a complete gall on March 19 (Table 1). Wasps of the genus *Aphidius* are parasitic on aphids (Muesebeck and Walkley, 1951a) and McLeod (1937) reared *A. phorodontis* from the peach aphid, *Myzus persicae* Sulzer. It is likely that the wasp reared from the gall was a parasite of an aphid on the gall. The specimen is deposited in the United States National Museum.

*Microgaster (comptanae* Vier.?)

One female wasp emerged from a complete gall on March 30 (Table 1). Muesebeck (1922) states that apparently most of the species of *Microgaster* are solitary parasites, always of Lepidoptera. The specimen may have been a parasite of a caterpillar feeding on the foliage of the willow.

## PLATYGASTERIDAE

*Leptacis* sp.

Two wasps emerged from the collection of *Dasyneura* cocoons, Lot 3C (Table 4), a male on May 16 and a female on May 19. It is thus evidently a parasite of the inquiline fly, *Dasyneura (albovittata?)*. Fouts (1924) gives no host records for the species in his key but reports collections of adults from leaves of trees. In the related genus *Platygaster* he records several species as parasites of itonidid galls, including galls on willow.

## CERAPHRONIDAE

*Lygocerus* sp.

Two wasps appeared from one complete gall, one on March 18 and the other on March 23 (Table 1). Clausen (1940) records that wasps of this genus are secondary parasites of aphids through *Aphidius* spp. It is possible that the two wasps from the gall were parasites of *Aphidius phorodontis* Ashm.

*Ceraphron* sp.

A single wasp emerged on May 1 from the collection of *Dasyneura* cocoons, Lot 3C (Table 4) and is thus evidently a parasite of the inquiline fly *D. (albovittata?)*. Muesebeck and Walkley (1951b) assert that the host relations of few species in the family Ceraphronidae are known.

## EULOPHIDAE

*Tetrastichus* sp.

These wasps were among the commonest of the parasites and emerged from 53 of the complete galls (Table 1). They are evidently parasites of *D. (albovittata?)* since they emerged also from the *Dasyneura* cocoons (Table 4) and from the larvae found among the scales (Table 3). Burks (1943) lists several galls as being hosts of various species of *Tetrastichus*, including some itonidid galls, but does not include the Pine Cone Willow gall. Four male and four female specimens are deposited in the Canadian National Collection.

*Pleurotropis* sp.

A single wasp emerged on May 3 from a complete gall (Table 1) and consequently its exact host remains undetermined. Peck (1951) lists many lepidopterous and dipterous hosts for species of *Pleurotropis*.

## ENCYRTIDAE

*Copidosoma* sp.

This parasite was the commonest emergent from the galls and there were approximately three times as many females as males (Table 5). Several cores in Lot 2 (Table 2) produced specimens of *Copidosoma* so it is evidently a parasite of the originator of the gall, *Rhabdophaga strobiloides*. Living wasps (1 ♂, 5 ♀ ♀) emerged from only one complete gall on April 6 (Table 1) but many were found dead when the galls were opened in mid-June. They were closely packed in the central core of the gall and ranged in number from one per gall to as many as nine (e.g. 4 ♂ ♂, 5 ♀ ♀), and in some cases there were females only (e.g. 5, 6 or 7 ♀ ♀). The maximum number from one core in Lot 2 (Table 2) was 12 (4 ♂ ♂, 8 ♀ ♀). The species of *Copidosoma* are polyembryonic (Clausen, 1940) and it is likely that all wasps in a single core of a gall were from a single egg. One male and six female specimens are deposited in the Canadian National Collection.

## PTEROMALIDAE

*Asaphes rufipes* Brues

A single male emerged on March 28 from a complete gall (Table 1). Peck (1951) lists several aphids as hosts of this and other species of *Asaphes* and it is likely that the specimen was a parasite or hyperparasite of an aphid on the gall.

*Tridymus* sp.

Six wasps were collected, four from four complete galls when opened in June (Table 1) and one female on April 17 and one male on April 23 from two of the cores in Lot 2 (Table 2). The latter two were thus either parasites or hyperparasites of *Rhabdophaga strobiloides*. Peck (1951) lists one species of *Tridymus* as having *Rhabdophaga salicis* for its host. The two specimens from the cores are deposited in the United States National Museum.

## TORYMIDAE

*Torymus strobiloides* (Huber)

Fourteen wasps emerged from the galls, eleven from complete galls (Table 1) and three from three cores (Table 2). They are thus parasites of *Rhabdophaga strobiloides* and the species is listed as such by Huber (1927) and Peck (1951). When a wasp emerged from a core it did so through a circular hole about 1 mm. in diameter in the side of the core (Fig. 5).

*Torymus* sp.

Sixteen wasps were collected, 13 from nine complete galls (Table 1) and three reared from larvae from among the scales, Lot 3B (Table 3). The wasp is thus evidently a parasite of the inquiline fly *Dasyneura (albovittata?)*. Huber (1927) states that the majority of the species of this genus (= *Callimome*) are parasites of either hymenopterous or dipterous gallmakers and he lists many hosts among the gall midges (Itonididae) including several species of *Dasyneura*.

## CYNIPIDAE

*Charips* sp.

A single female emerged from a complete gall on April 10 (Table 1). Weld (1951) lists various aphids as hosts of *Charips* and Clausen (1940) reports one species as a parasite of *Aphidius ervi* Hal. It is likely that the wasp from the gall was a hyperparasite of an aphid on the gall, possibly through the wasp *Aphidius phorodontis* Ashm.

## ORTHOPTERA

## TETTIGONIIDAE

Tettigoniid eggs were found among the larger, outer scales of the galls (Fig. 3A). Altogether 397 eggs were found in 63 (15.9%) of the galls, the maximum number in a single gall being 28 and the average number six. Eggs from 50 galls were placed in vials for rearing (Lot 3A) but no nymphs or parasites emerged from them. Blatchley (1920) recounts that the grasshopper *Conocephalus brevipennis* (Scudder) commonly lays its eggs in galls of willow and quotes accounts of other authors describing the process of oviposition. *C. brevipennis* is a common species in Southern Ontario, being usually found in marshy areas (Urquhart, 1941) and it was probably the species which laid the eggs in the galls.

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Table I.

LOT 1: EMERGENTS FROM 150 COMPLETE GALLS, Collected March 3, 1951

Insects	Number of galls	Emergents			Emergence		Dates
		♂	♀	Total	First	Peak	Last
DIPTERA							
Itonididae							
<i>Rhabdophaga strobilioides</i>	6	1	5	6	Mar. 23	Mar. 27	Apr. 1
<i>Dasyneura (albovittata?)</i>	17	9	14	23	Mar. 31	May 5	May 15
HYMENOPTERA							
Braconidae							
<i>Diaeretus salicaphis</i>	6	2	5	7	Mar. 17	Mar. 18	Mar. 23
<i>Aphidius phorodontis</i>	1	?	?	1		Mar. 19	
<i>Microgaster</i> sp.	1		1	1		Mar. 30	
Ceraphronidae							
<i>Lygocerus</i> sp.	1	?	?	2	Mar. 18		Mar. 23
Eulophidae							
<i>Tetrastichus</i> sp.	53	52	70	122	Apr. 20	May 10	June 14
<i>Pleurotropis</i> sp.	1	?	?	1		May 3	
Encyrtidae							
<i>Copidosoma</i> sp.	33	47	150	197		Apr. 6	
Pteromalidae							
<i>Asaphes rufipes</i>	1	1		1		Mar. 28	
<i>Tridymus</i> sp.	4	?	?	4			
Torymidae							
<i>Torymus strobiloides</i>	11	6	5	11	May 8		May 22
<i>Torymus</i> sp.	9	8	5	13	Apr. 2		June 12
Cynipidae							
<i>Charips</i> sp.	1		1	1		Apr. 10	
Tenthredinidae							
<i>Amauronematus</i> sp.	1		1	1		Mar. 17	

Table II.

LOT 2: EMERGENTS FROM 50 CORES OF GALLS COLLECTED March 10, 1951

Insects	Emergents			Emergence Dates		
	♂	♀	Total	First	Peak	Last
DIPTERA						
Itonididae						
<i>Rhabdophaga strobiloides</i>	3	17	20	Mar. 28	Mar. 29	Apr. 1
HYMENOPTERA						
Encyrtidae						
<i>Copidosoma</i> sp.	25	87	112	Apr. 6	Apr. 7	Apr. 13
Pteromalidae						
<i>Tridymus</i> sp.	1	1	2	Apr. 17		Apr. 23
Torymidae						
<i>Torymus strobiloides</i>	1	2	3	May 23		May 31

Table III.

LOT 3B: EMERGENTS FROM LARVAE AMONG SCALES OF 50 GALLS, COLLECTED March 31, 1951

Insects	Emergents			Emergence Dates		
	♂	♀	Total	First	Peak	Last
HYMENOPTERA						
Eulophidae						
<i>Tetrastichus</i> sp.	5	7	12	Apr. 26	May 3	May 5
Torymidae						
<i>Torymus</i> sp.	2	1	3	May 16		June 8

Table IV.

LOT 3C: EMERGENTS FROM COCOONS AMONG SCALES OF 50 GALLS, COLLECTED March 31, 1951

Insects	Emergents			Emergence Dates		
	♂	♀	Total	First	Peak	Last
DIPTERA						
Itonididae						
<i>Dasyneura (albovitata?)</i>	28	56	84	Apr. 13	Apr. 14	May 9
HYMENOPTERA						
Platygasteridae						
<i>Leptacis</i> sp.	1	1	2	May 16		May 19
Ceraphronidae						
<i>Ceraphron</i> sp.	?	?	1		May 1	
Eulophidae						
<i>Tetrastichus</i> sp.	1	11	12	May 6	May 14	May 28

Table V.  
SUMMARY OF ALL EMERGENTS

Insects	♂	%	♀	%	Total	Status
Diptera						
Itonididae						
1. <i>Rhabdophaga strobiloides</i>	4	15.4	22	84.6	26	causes gall
2. <i>Dasyneura (albovittata?)</i>	37	34.5	70	65.5	107	inquiline
HYMENOPTERA						
Braconidae						
3. <i>Diaeretus salicaphis</i>	2	28.6	5	71.4	7	?
4. <i>Aphidius phorodontis</i>	?		?		1	?
5. <i>Microgaster</i> sp.			1	100	1	?
Platygasteridae						
6. <i>Leptacis</i> sp.	1	50.0	1	50.0	2	parasite of <i>Dasyneura</i>
Ceraphronidae						
7. <i>Lygocerus</i> sp.	?		?		2	?
8. <i>Ceraphron</i> sp.	?		?		1	parasite of <i>Dasyneura</i>
Eulophidae						
9. <i>Tetrastichus</i> sp.	58	39.7	88	60.3	146	parasite of <i>Dasyneura</i>
10. <i>Pleurotropis</i> sp.	?		?		1	?
Encyrtidae						
11. <i>Copidosoma</i> sp.	72	23.3	237	76.7	309	parasite of <i>Rhabdophaga</i>
Pteromalidae						
12. <i>Asaphes rufipes</i>	1	100			1	?
13. <i>Tridymus</i> sp.	?		?		6	parasite of <i>Rhabdophaga</i>
Torymidae						
14. <i>Torymus strobiloides</i>	7	50.0	7	50.0	14	parasite of <i>Rhabdophaga</i>
15. <i>Torymus</i> sp.	10	62.5	6	37.5	16	parasite of <i>Dasyneura</i>
Cynipidae						
16. <i>Charips</i> sp.			1	100	1	?
Tenthredinidae						
17. <i>Amauronematus</i> sp.			1	100	1	spun cocoon

## LEGEND FOR FIGURES

(Page 44)

- Fig. 1 — Core of gall dissected to show larva of *Rhabdophaga strobiloides*.  
 Fig. 2 — Pupal skin of *Rhabdophaga strobiloides* projecting from tip of gall.  
 Fig. 3A — Tettigoniid eggs on scale of gall.  
 Fig. 3B — *Dasyneura* cocoons on scale of gall.  
 Fig. 4 — Pupa of *Dasyneura* projecting from tip of cocoon.  
 Fig. 5 — Core of gall showing emergence hole of *Torymus strobiloides*.  
 Fig. 6 — Cocoon of *Amauronematus* sp. at base of gall.



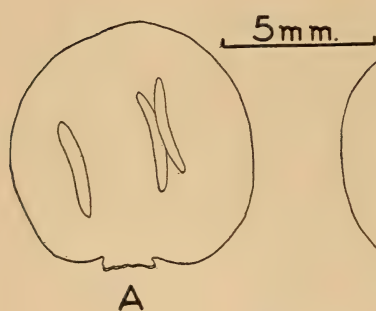
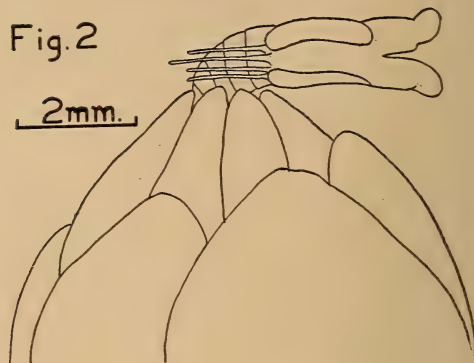
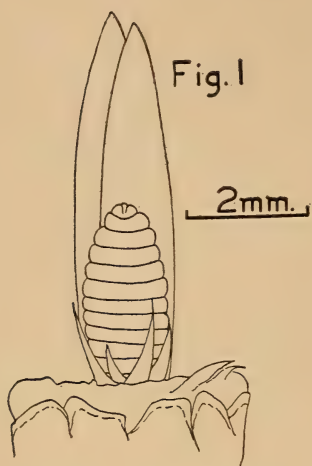
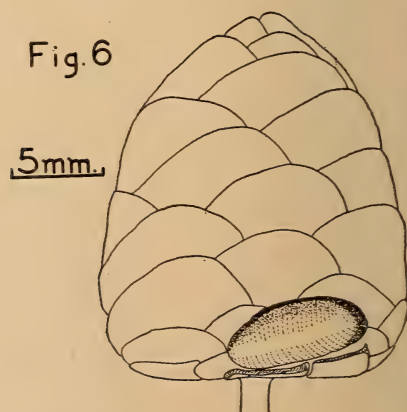
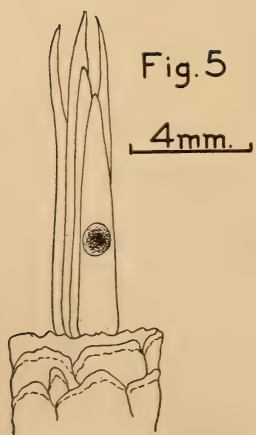
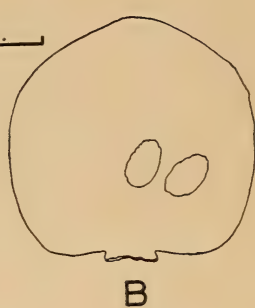


Fig.3



# INCREASE OF THE MULTIVOLTINE STRAIN OF THE EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* (HBN.) (LEPIDOPTERA: PYRALIDAE), IN SOUTHWESTERN ONTARIO<sup>1</sup>

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The European corn borer, *Pyrausta nubilalis* (Hbn.), has been a serious pest of corn in Ontario for over 30 years. From 1920 to 1940, the borer was mainly a single-generation species; a trace of a second generation was present during some years. About 1941, a noticeable change took place in the life history of the borer. The percentage of second-generation borers increased so that in 1951 this strain formed an important part of the borer population.

Ficht and Hienton (6), working in Indiana between 1935 and 1938, showed that a second generation of the European corn borer was increasing in that region. This was the first indication of any change in status of this strain. Vance (8), in 1942, reported that in Indiana and certain localities in Ohio the borer could be regarded as a two-generation pest.

In southern Ontario, development of a multivoltine strain of the borer followed a pattern similar to that in the neighbouring states, with an evident time lag of 2 or 3 years. Crawford and Spencer (4) mentioned finding pupae in sweet corn at midsummer in 1921, when the borer first appeared as a pest in the province. This represented only a fraction of 1 per cent of the population. In 1931, Caesar and Thompson (3) found that a small second generation occurred in a long, warm season. Arnott (2), by means of light trap and summer pupation records, showed that from 1931 to 1941 the second-generation increase was apparently negligible.

In 1942, Wishart (9), while studying parasites of the corn borer in Essex County, noted an increase in the summer pupation of the borer larvae. The development of the multivoltine strain became more evident in 1943 when Wishart (10) again recorded a definite increase in summer pupation. The average pupation during the summer in 1941 was only 2.25 per cent, as compared with 13.03 per cent in 1943.

The author, in annual field infestation surveys made in the fall from 1946 to 1951, recorded the increase and spread of the multivoltine strain in the 5 southwestern counties of Ontario. This reached its highest point in 1949, a year favourable to borer development (11). Ninety-seven per cent of the fields visited in the 1949 survey showed evidence that the multivoltine strain was then predominant.

## METHODS AND TECHNIQUE

The light trap used in this study was modified from that of de Gryse (5) by removing the glass baffles and screens and providing a protective cover. A frosted 100-watt bulb, operating on 25-cycle current and placed 10 feet above the ground, attracted the moths. Calcium cyanide was placed in a copper container at the bottom of the trap. This container was about 40 inches from the source of light. The calcium cyanide was renewed every 3 to 5 days, depending on atmospheric conditions. The trap was in operation from May 15 to October 31, except from 1945 to 1951, when the last date of operation was September 30. The moths were counted, sorted according to sex, and recorded daily, except when longer intervals occurred between examinations.

Moths taken after a moth-free interval of 7 days in August were considered to belong to the multivoltine strain. It is obvious that there was an overlapping of first- and second-generation moths in late July and early August. Moths flying after mid-August belonged to the multivoltine strain.

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As a check on the light trap located at Chatham, a second trap was operated frequently at the Experimental Station, Harrow, Ontario, 56 miles southwest of Chatham, where the corn borer infestation has been severe every year.

### RESULTS AND DISCUSSION

The total numbers of moths taken during 5-day periods for each 5-year interval are shown in Fig. 1. The trend in the development of the multivoltine strain is very evident. A summary of the main details of the flight (TABLE I) shows that even in 1934 moths were flying as late as October. This established that the multivoltine strain was present in Ontario at least since that year.

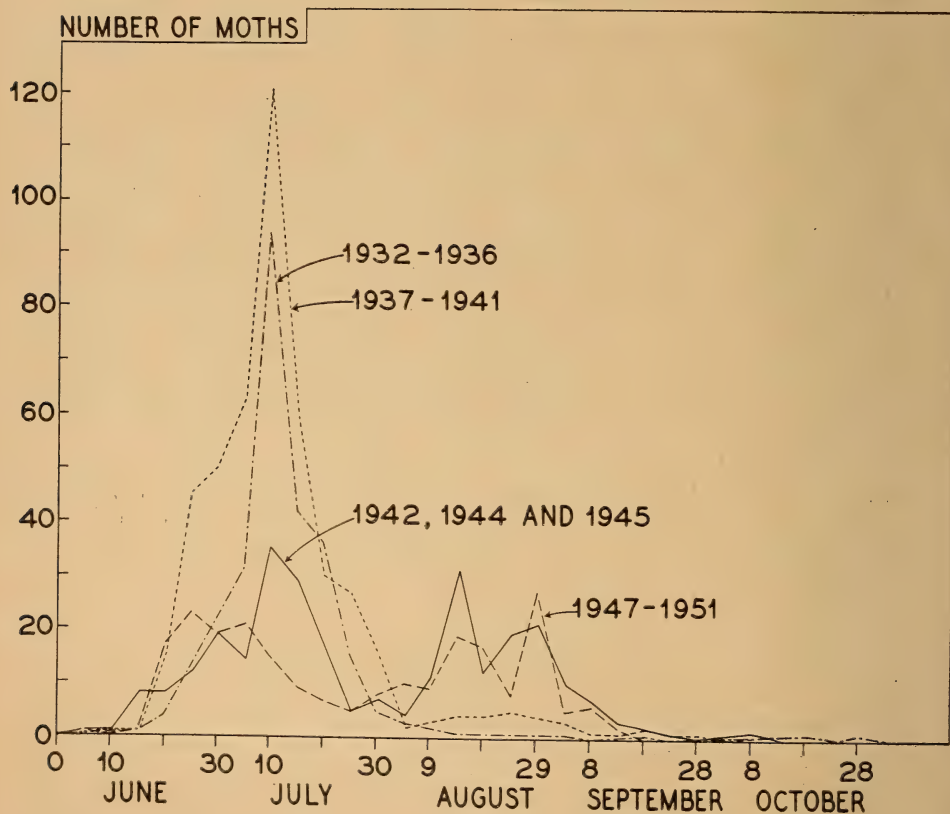


Fig. 1

Fig. 1. Average numbers of *Pyrausta nubilalis* (Hbn.) caught in a light trap, Chatham, Ont., during 5-year periods, 1932-1951 (trap not operated in 1943 and 1946).

From 1932 to 1936, at least 97 per cent of the population belonged to the single-generation strain. The moth flight increased progressively during the season and reached its peak not later than July 14. The flight dropped abruptly after the peak, but the appearance of second-generation moths in early August sustained it until September in 1934-1936. Two very late moths appeared in October in 1934 and 1936.



TABLE I.—SUMMARY OF FLIGHTS OF EUROPEAN CORN BORER ADULTS AS INDICATED BY LIGHT TRAP COLLECTIONS, CHATHAM, ONTARIO, 1932 TO 1951

<i>Year</i>	<i>First date of flight to trap</i>	<i>Last date of flight to trap</i>	<i>Peak date of flight to trap</i>	<i>Total moths captured</i>	<i>Per cent female moths</i>	<i>Per cent second generation</i>
1932	June 18	Aug. 26	July 6	232	25.0	2.0
1933	11	July 31	June 24	183	22.5	0.0
1934	20	Oct. 1	July 12	277	15.5	1.0
1935	30	Sept. 24	July 14	162	22.0	3.0
1936	25	Oct. 26	July 8	735	39.5	2.5
1937	17	Sept. 8	July 9	526	31.5	2.5
1938	11	Oct. 16	July 5	552	40.0	6.0
1939	7	Sept. 28	July 7	283	34.5	13.0
1940	9	Sept. 20	July 13	295	29.0	9.5
1941	7	Oct. 12	July 6	627	30.0	5.5
1942	18	Oct. 8	July 11	321	37.5	32.0
1943	—	—	—	—	—	—
1944	5	Oct. 5	Aug. 11	254	44.5	48.0
1945	18	Sept. 22	Aug. 23	263	30.0	55.0
1946	—	—	—	—	—	—
1947	15	Sept. 14	June 29	205	58.0	29.0
1948	20	Sept. 18	July 5	95	25.5	30.0
1949	3	Sept. 3	June 19	435	50.0	49.0
1950	25	Sept. 14	July 3	159	45.5	47.0
1951	17	Sept. 13	Aug. 27	285	38.5	71.0

From 1937 to 1941, the multivoltine strain increased to an average of over 7 per cent of the total moth population. The increase was especially noticeable in 1939 and 1940. The figure for 1939 is given as 13 per cent, which may be high because the line of demarcation between first- and second-generation flight was not clearly defined. No such difficulty was encountered in 1940, when there was a 2-week interval between the two flights. Nearly 10 per cent of the moths in 1940 belonged to the multivoltine strain. There was a heavy flight in 1941, but the multivoltine strain formed less than 6 per cent of the population.

The light trap was not operated in 1943 and 1946. Consequently, 1942, 1944, and 1945 are considered as a 3-year unit. Before this period it was uncertain whether the increase in the 2-generation strain was actually a trend or only seasonal fluctuations in numbers. Any doubt was dispelled during 1942, which appears to have been a critical year in the development of the multivoltine strain in southwestern Ontario. In that year, 34 per cent of the moths belonged to the second generation. In 1944 not only did the 2-generation strain increase so that it represented nearly 47 per cent of the moths taken, but for the first time a second peak of flight occurred, in mid-August. In 1945, the majority of the moths captured in the light trap belonged to the multivoltine strain and over 54 per cent of the moths were taken after July 31.

There was a reduction in the number of multivoltine moths in 1947 and 1948 to 29 and 30 per cent, respectively. However, in 1949 the multivoltine strain constituted 49 per cent of the total population. A slight reduction of second-generation moths took place in 1950. In 1951, there was more reliable evidence that this strain might become the predominant one in southwestern Ontario. The flight was moderately heavy, and 71 per cent of the moths belonged to the multivoltine strain. A second peak of the average captures for 1947 to 1951 occurred in late August. This contrasts markedly with the years up to 1941, when the peak occurred about the middle of July.

TABLE II shows the comparison between the moth captures made at Chatham, and those at Harrow for the 3 years during which the Harrow trap was in operation. There was a general increase of multivoltine moths at both stations.

TABLE II.—COMPARISON OF THE FLIGHTS OF EUROPEAN CORN BORER MOTHS TO LIGHT TRAPS AT CHATHAM AND HARROW, ONT., 1947, 1950, AND 1951

<i>Year</i>	<i>Total moths</i>	<i>Peak date of flight</i>	<i>Per cent second generation</i>
Chatham			
1947	205	June 29	29
1950	159	July 3	47
1951	285	Aug. 27	71
Harrow			
1947	348	July 9	27
1950	1257	Aug. 24	68
1951	783	Aug. 27	81

#### GENERAL DISCUSSION AND CONCLUSIONS

For nearly 20 years, from 1920 to 1938, the European corn borer was regarded as a single-generation pest in southwestern Ontario. A critical examination of the light trap data accumulated at Chatham shows that a multivoltine strain increased markedly in numbers from 1942 to 1951.

The increase of the two-generation borer in southwestern Ontario is important from an economic standpoint. The canning corn industry has been especially affected. First-generation larvae do little damage to canning corn since most of the infestation is confined to the stalk. These larvae are usually full-grown at harvest time, and any found in the ear can be washed out at the factory. With the increase of the multivoltine strain, a new problem has arisen in the canning corn industry. The second-generation moth usually lays her eggs on or near the guard leaves surrounding the ears. Upon hatching, the young larvae bore into the husks and kernels, and many of them are in the second instar when the corn is packed. Since they are in the kernels, they cannot be washed out by ordinary methods and they are frequently overlooked during the canning process. Consequently, complaints are often received from consumers regarding the presence of larvae in both whole-kernel and cream-style corn. As a result of this increase in the multivoltine strain, the canning companies in southwestern Ontario have been forced to adopt careful control measures. This involves the use of costly power sprayers and dusters.

A further problem that has arisen is the infestation of sweet peppers by multivoltine borers (12). As pointed out by McKen (7), the borer is responsible for (a) initial infestation in the pepper fruit, and (b) a wound which allows the entry of the soft rot organism, *Erwinia carotovora* (Jones) Holland. The borer also transfers the soft rot from fruit to fruit. The possibility of infestation of sweet peppers by second-generation borers is of grave concern to growers in Kent and Essex counties, where this valuable crop is mainly grown.

The increase of the multivoltine strain appears to be still in progress. This is indicated by the facts that in 1951, 71 per cent of the moths, the highest percentage recorded, belonged to the second generation, and that from 1947 to 1951 a second peak for the average captures occurred in late August. Furthermore, the borer has recently become a pest of peppers even when its favourite host, sweet corn was plentiful in the same district. There is every indication that the multivoltine strain may eventually become the predominant strain in Ontario. The

reason for this change in status is not known. Arbuthnot (1), in his study of the effect of climate on corn borer reproduction, has suggested a possible explanation. He states that both strains may be present in a region, but the less-favoured strain may have reached the region ahead of the one best suited to survive in the environment. In time, equilibrium is reached, and the strain best suited to the region will predominate. More intensive research in corn borer genetics is necessary before this theory can be accepted.

#### SUMMARY

The European corn borer was formerly regarded as a single-generation pest in southwestern Ontario. A scarcely discernible second generation was known to be present during some seasons. The increase in the multivoltine strain is shown by the flight of adults to a light trap near Chatham, Ontario. From 1932 to 1951, the multivoltine strain increased from less than 2 to more than 71 per cent of the moth population. Increase was rapid after 1942, and largely progressive. This indicates that the multivoltine strain may eventually predominate in southwestern Ontario. The reason for this change in status is not known.

#### ACKNOWLEDGMENTS

The author wishes to thank D. A. Arnott, now of the Field Crop Insect Section, Laboratory of Entomology, Kamloops, B.C., who was responsible for the maintenance of the light trap from 1932 to 1941.

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# ANNOTATED CATALOGUE OF INSECT AND OTHER INVERTEBRATE PESTS OF TOBACCO IN CANADA<sup>1</sup>

C. J. S. FOX<sup>2</sup> AND G. M. STIRRETT<sup>3</sup>

## INTRODUCTION

This paper brings together the scattered records on the insects associated with tobacco in the plant bed and in the field in Canada. The observations have been made chiefly by officers of the Division of Entomology in Ontario, Quebec, and British Columbia during the past 20 years or more.

Tobacco growing on a commercial scale in Canada is now a major agricultural enterprise. In 1950, according to the Dominion Bureau of Statistics, 101, 809 acres were planted to tobacco and produced 120,298,000 pounds, having a farm value exceeding \$51,000,000. The three tobacco-producing provinces contributed to these totals as follows:—

Province	Acreage	Production in Pounds	Farm Value
Ontario	92,556	110,610,000	\$48,505,000
Quebec	9,163	9,556,000	\$ 2,732,000
British Columbia	120	132,000	\$ 55,000

Valid estimates in dollars and cents of the injury to growing tobacco caused by its numerous pests are difficult to obtain. Estimates are usually about 10 per cent but there is little sound evidence for this figure.

The tomato hornworm, *Protoparce quinquemaculata* (Haw.), alone would, in certain years, destroy over 35 per cent of the tobacco crop if it were not controlled. Table I, computed on the basis of a yield of 1,240 pounds per acre, at 22 cents per pound to the grower, shows losses in pounds and dollars per acre for a number of unsprayed plots and fields.

Table I

LOSSES IN POUNDS AND DOLLARS PER ACRE CAUSED BY THE TOMATO HORN-  
WORM IN UNSPRAYED FIELDS AND PLOTS OF FLUE-CURED TOBACCO  
IN NORFOLK COUNTY, ONTARIO.

Year	Location	Leaves severely injured	Loss per acre	
		%	Lb.	\$
1938	Experimental Station, Delhi, Ont.	10	124	27.28
1939	Experimental Station, Delhi	35	434	95.48
1940	Experimental Station, Delhi, Field E	31	384	84.48
1940	Experimental Station, Delhi, Field C	6	74	16.28
1940	Norwood Farm, Lynedoch, Ont.	14	173	38.06

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Table I takes into account only the worthless and severely injured leaves, but there is additional damage caused by the larvae eating smaller portions of the leaves. The total leaf damage in the plots at the Canada Experimental Station, Delhi, Ont., in 1939 was over 52 per cent. With a higher current price for tobacco (44 cents in 1950), the monetary loss per acre would be correspondingly higher.

The annual spraying bill for Ontario to combat this one tobacco insect was estimated in 1945 to be in the neighbourhood of \$107,600. This included the application of about 200 tons of arsenate of lead. This material has now been replaced by DDT at slightly more than half the cost per acre.

Other major tobacco pests, such as aphids, cutworms, wireworms, and grasshoppers, also cause losses, but reliable figures are not available.

In the following annotated list the numbers immediately following the names of the insects refer to the tobacco districts in which they were found. The districts are numbered from west to east and are defined as follows:

1. The Sumas district is in the lower Fraser Valley in British Columbia.
2. The "Old Belt" comprises parts of the counties of Essex and Kent in extreme southwestern Ontario.
3. The "New Belt" comprises parts of the Ontario counties of Elgin and Norfolk and southern portions of Oxford and Brant.
4. The "Northern District" in Quebec lies north of Montreal and comprises parts of the counties of l'Assomption, Montcalm, Berthier, and Joliette.
5. The "Southern District" in Quebec lies south of Montreal along the valley of the Yamaska River and is centred in Rouville County.

References to the literature are indicated at the end of each notation on a species. For No. 22, the volumes and the numbers of *The Canadian Insect Pest Review* are given and are marked off by commas.

## PHYLUM ARTHROPODA

### CLASS INSECTA

#### ORDER COLEOPTERA

##### Family Chrysomelidae

*Diabrotica undecimpunctata howardi* Barber (spotted cucumber beetle) (2,3).—Not usually injurious to tobacco, but in some years severely destructive. Characteristically feeding on the growing points of young plants. (22, 21 (3), 23 (3), 24 (4), 25 (3).

*Epitrix hirtipennis* (Melsh.) (tobacco flea beetle) (2,3).—Found on tobacco only in 1933, but found on ground cherries, *Physalis* spp., which are common weeds in southwestern Ontario. (21).

*Phyllotreta striolata* (F.) (striped flea beetle) (2).—Found in a tobacco seed-bed in May, 1939, causing slight damage. (9).

*Systema taeniata* (Say) (2).—Observed feeding on tobacco, causing very little damage. (22, 26 (3)).

*Leptinotarsa decemlineata* (Say) (Colorado potato beetle) (2,3,4,5).—Occasionally feeding on tobacco. (14).

##### Family Coccinellidae

*Coleomegilla maculata lengi* Timb. (2,3), *Cycloneda munda* (Say) (2,3), *Coccinella novemnotata novemnotata* Hbst. (2,3), *Hippodamia convergens* Guér. (2,3), and *Hippodamia tridecimpunctata tibialis* (Say) (2,3).—Commonly found feeding on aphids on tobacco. (11).

*Family Elateridae*

*Agriotes mancus* (Say) (wheat wireworm) (2,3).—Typically found in the heavier tobacco soils. (7).

*Aeolus mellillus* (Say) (flat wireworm) (2).—A common wireworm in areas having heavier soil suitable for burley tobacco. Readily found and always causing some damage. Life-cycle completed in one year. In Canada apparently restricted to southwestern Ontario and Western Canada. (15; 22, 19 (3), 22 (3)).

*Ctenicera aeripennis aeripennis* (Kby.) (Puget Sound wireworm) (1).—Reported damaging tobacco in 1946. (22, 24 (8)).

*Limonijs infuscatus* Mots. (western field wireworm) (1).—Reported damaging tobacco in 1946. (22, 24 (8)).

*Limonijs agonus* (Say) (eastern field wireworm) (2,3,4,5).—The most abundant and injurious wireworm in Ontario. In some years reported as extremely injurious. (19; 22, 24 (8), 25 (3)).

*Ctenicera* spp. (2).—Reported to have injured tobacco. (5; 6; 22, 22 (3)).

*Melnotus divarcarinus* Blatch. (2).—Found injuring burley tobacco in Kent County, Ontario. (6).

When wireworm injury to tobacco was reported, the species involved were usually not mentioned. Consequently, out of the mass of references to wireworms, only generalities of limited value can be deduced. Damage to tobacco seems to fluctuate considerably. Recent periods of exceptionally severe and widespread injury in southwestern Ontario were 1930-31, 1938, 1940-41, and 1946.

*Family Scarabaeidae*

*Macroductylus subspinosus* (F.) (rose chafer) (2,3).—Occasionally injurious in years of high populations and especially in sandy areas. Attack on tobacco probably incidental, the adults having emerged in fields planted to the crop. Most beetles seen in such fields were in copulation. (22, 17 (2), 22 (3), 26 (3)).

## ORDER COLLEMBOLA

*Family Isotomidae*

*Proisotoma minuta* (Tullb.) (2).—Reported present in millions in plant beds, causing considerable injury. (22, 16 (2)).

*Xenylla welchi* Fols. (2).—Frequently found injuring tobacco seedlings. (22, 16 (2), 24 (2)).

*Family Sminthuridae*

*Bourletiella hortensis* (Fitch) (garden springtail) (2).—Nearly always present in plant beds, at times severely injuring seedlings. (22, 5 (2)).

## ORDER DIPTERA

*Family Anthomyiidae*

*Hylemya cilicrura* (Rond.) (seed-corn maggot) (2).—Usually a minor pest of tobacco, but high populations and considerable damage reported in 1931 and 1944. (21; 22, 9 (3), 22 (3)).

*Family Tipulidae*

*Nephrotoma* spp. (3).—Field tobacco slightly injured by larvae. (22, 25 (2)).



## ORDER HEMIPTERA

## Family Miridae

*Lygus oblineatus* (Say) (tarnished plant bug) (2,3).—Occasionally feeding on tobacco. (1).

*Euschistus variolarius* (P.B.) (2,3).—Prevalent every year with occasional severe infestations. (22, 19 (4) 27 (4)).

## ORDER HOMOPTERA

## Family Aleyrodidae

*Trialeurodes vaporariorum* (Westw.) (greenhouse whitefly) (2).—Often found in parts of tobacco fields shaded by trees. (22, 26 (5)).

## Family Aphididae

*Myzus persicae* (Sulz.) (green peach aphid) (2,3).—Seen in injurious numbers for the first time on July 31, 1947, south of St. Thomas and Chatham, Ontario. Every year since, irregular areas of severe infestation have extended from Simcoe to Harrow, chiefly along the north shore of Lake Erie. (22, 26 (1), 26 (6), 30 (1)).

*Aphis mcidis* Fitch, *Aphids rumicis* (L.), and *Drepanaphis acerifoliae* (Thos.).—Found on tobacco in Ontario in 1942. As no thriving colonies seen, presence no doubt incidental. (10).

## Family Cercopidae

*Philaenus leucophthalmus* (L.) (meadow spittlebug) (2).—Feeding on the mid-veins of tobacco leaves. Sometimes numerous but apparently doing little damage. (22, 26 (3)).

## ORDER LEPIDOPTERA

## Family Arctiidae

*Estigmene acrea* (Drury) (salt-marsh caterpillar) (5).—Found injuring tobacco at l'Ange Gardien, Quebec. (22, 12 (4)).

## Family Phalaenidae

*Graphiphora c-nigrum* (L.) (spotted cutworm) (3).—Found feeding on tobacco seedlings in greenhouses. (22, 26 (2)).

*Crymodes devastator* (Brace) (glassy cutworm) (2,3,4,5).—Commonly found injuring tobacco. (22, 20 (4)).

*Euxoa messoria* (Harr.) (dark-sided cutworm) (2,3,4,5).—A climbing cutworm. Always found associated with tobacco, often causing severe losses of newly set plants. (4; 22, 20 (4), 21 (3), 22 (3)).

*Euxoa tessellata* (Harr.) (striped cutworm) (2,3,4,5).—Common, and occasionally very injurious. (22, 20 (4), 21 (3), 22 (3)).

*Feltia subgothica* (Haw.) (dingy cutworm) (2,3,4,5).—Commonly found in tobacco fields. (4; 22, 20 (4)).

*Agrotis ypsilon* (Rott.) (black cutworm) (2,3,4,5).—Commonly found injuring tobacco. (13; 22, 26 (3)).

*Mamestra configurata* Wlkr. (bertha armyworm) (1).—Reported to have injured tobacco in 1938. (3).

*Euxoa detersa* (Wlkr.) (3).—Probably common, but recorded only in 1942, 1943, and 1944. (22, 20 (4), 21, (3), 22 (3)).

*Apamea amputatrix* (Fitch) [= *Septis arctica* (Freyer)] (yellow-headed cutworm) (2,3).—An underground feeder. Rarely noticeably injurious. (20).

*Peridroma margaritosa* (Haw.) (variegated cutworm) (2,3,4,5).—Nearly always present and injurious in tobacco fields. (22, 16 (2), 23 (3), 26 (4)).

*Polia meditata* (Grt.) (3).—Found injuring tobacco seedlings in 1948. (22, 27 (1B)).

*Spaelotis clandestina* (Harr.) (w-marked cutworm) (2,3).—A climbing cutworm; nearly always present in tobacco fields but rarely in large numbers. (22, 20 (4)).

*Heliothis armigera* (Hbn.) (corn earworm) (2,3).—Attacking tobacco to a minor extent. (1).

*Heliothis virescens* (F.) (tobacco budworm) (2,5).—Occasionally injurious in small, localized areas. (22, 17 (4), 27 (5)).

*Papaipema nebris* (Guen.) (stalk borer) (2,3,5).—A minor pest but sometimes common. (22, 25 (4), 16 (3,4)).

*Prodenia ornithogalli* Guen. (yellow-striped armyworm) (2).—Found feeding on tobacco in 1949. (22, 27 (4)).

*Trichoplusia ni* (Hbn.) (cabbage looper) (2,3).—Found occasionally on tobacco but causing little injury. (8).

#### Family Nymphalidae

*Vanessa cardui* (L.) (painted-lady) (2).—Found feeding on tobacco in 1949. (22, 27 (4)).

#### Family Pyralididae

*Crambus ccliginosellus* Clem. (corn root webworm) (2,3,5).—Causing considerable damage to tobacco in some years. (8; 22, 25 (1)).

*Crambus luteolellus* Clem. (2,3).—Reported to have injured tobacco. (4; 5; 22, 25 (1)).

*Crambus trisectus* (Wlk.) (2,3).—Occasionally in outbreak proportions on tobacco in Ontario. (22, 14 (1)).

*Nomophila noctuella* (Schiff.) (2).—Occasionally feeding on tobacco but usually on clovers and grasses. (22, 16 (3)).

*Pyrausta nubilalis* (Hbn.) (European corn borer) (2,3).—Found infesting tobacco grown beside corn. (18).

#### Family Sphingidae

*Protoparce sexta* (Johan.) (tobacco hornworm) (2).—A southern species taken for the first time in Canada in Essex County, Ontario, in 1939. Collected almost every year since. Probably always present in varying numbers. (22, 17 (4), 24 (1)).

*Protoparce quinquemaculata* (Haw.) (tomato hornworm) (2,3,4,5).—Called the "tobacco worm" by tobacco growers. The most important insect enemy of tobacco in Canada. Larvae voracious feeders on the leaves and artificial control usually necessary. Parasitized chiefly by the braconid *Apanteles congregatus* (Say). Parasitism sometimes over 90 per cent in late summer. (22, 1-29).

### ORDER ORTHOPTERA

#### Family Locustidae

*Camnula pellucida* (Scudd.) (clear-winged grasshopper) (2,3).—Not common, but occasionally feeding on tobacco. (16).

*Chortophaga viridifasciata* Deg. (5).—A minor pest of tobacco in Quebec. (2).

*Dissosteira carolina* (L.) (Carolina grasshopper) (2,3).—Always somewhat destructive and in some years an important pest. (22, 23 (3)).

*Encoptolophus sordidus* (Burm.) (2).—Occasionally injurious in late summer. Not widespread. (22, 26 (6)).

*Melanoplus mexicanus mexicanus* (Sauss.). (lesser migratory grasshopper) (2,3,4,5).—Nearly always somewhat destructive to tobacco. (2,16).

*Melanoplus bivittatus* (Say) (two-striped grasshopper) (5).—Reported to have injured tobacco. (2).

*Melanoplus femur-rubrum* (Deg.) (red-legged grasshopper) (2,3).—Always somewhat injurious and occasionally abundant enough to damage fields seriously. (22, 22 (1), 23 (3)).

*Scudderia furcata* Brunn. (fork-tailed bush katydid) (2,3).—Scarce in tobacco fields, but injurious to individual plants. (22, 27 (1B)).

*Scudderia texensis* Sauss.-Pict. (5).—Reported to have injured tobacco. (2).

#### Family Gryllidae

*Acheta assimilis* F. (field cricket) (3).—Reported to have injured tobacco in Norfolk County, Ontario. (22, 22 (1)).

*Oecanthus nigricornis nigricornis* Wlkr. (black-horned tree cricket) (2,3).—Somewhat injurious to tobacco. (11, 23).

*Oecanthus nigricornis quadripunctatus* Beut. (four-spotted tree cricket) (2,3).—A scarce and minor pest. (11, 23).

*Oecanthus niveus* (Deg.) (snowy tree cricket) (2,3).—Always slightly injurious. (11).

#### Family Tettigoniidae

*Neoconocephalus ensiger* (Harris) (2,3).—Occasionally seen feeding on tobacco. (11).

### PHYLUM MOLLUSCA

#### Family Limacidae

Garden slugs have been mentioned as being injurious at times in Ontario and Quebec but specific records are lacking. (22, 9 (3)).

### PHYLUM NEMATODA

#### CLASS PHASMIDIA

#### Family Heteroderidae

*Meloidogyne* sp. (root-knot nematode) (3).—A common eelworm. Said to cause considerable injury to tobacco in some years at Delhi, Ontario. (22, 21 (3)).

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## PLANTING-WATER TREATMENTS FOR THE CONTROL OF WIREWORMS IN TOBACCO<sup>1</sup>

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The eastern field wireworm, *Limonius agonus* (Say), is the most important species of wireworm attacking tobacco in southwestern Ontario. Untreated fields frequently have to be replanted once or twice because of wireworm damage. Stems or roots of transplants may be tunnelled or severed. When damage is apparent, plants are replaced immediately. If the damage is less severe, replacement may be delayed until too late for the leaves to mature.

Many wireworms may feed on one plant, but one is usually sufficient to kill it. Between 6 and 7 square feet of land are allowed for a tobacco plant. One wireworm per square foot, a comparatively light infestation, often results in 6 or 7 wireworms attacking each plant. Hence, a high degree of protection is necessary to prevent severe damage.

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Conditions favouring tobacco growing also favour the eastern field wireworm. They prefer sandy or sandy loam soils, which are also the most suitable for tobacco growing. The extensive cultivation necessary for good tobacco production also favours this species, the female usually ovipositing in loose, cultivated land. Similar increases in the wireworm population have been noted in land devoted to potatoes and corn, where cultivation also is extensive. Tobacco land is cultivated frequently before planting, when wireworms normally feed heavily. Therefore, when the tobacco is transplanted the wireworms, deprived of their earlier food supply, centre their attack on the young, succulent plants.

Cultural practices to date have proved unsatisfactory for control. In the past, many methods of chemical control had been tried with little success. The new organic insecticides, however, have made efficient and economical wireworm control possible for the first time.

In 1947 D. S. Marshall, then of the Chatham laboratory, experimenting with BHC, obtained promising control of wireworms attacking flue-cured tobacco. Since that year, BHC, drilled into the ground either as a dust or mixed with fertilizer, has been the accepted means of wireworm control in southwestern Ontario. BHC, however, is disagreeable to apply, and taints root crops grown in treated soil for at least 3 years after application.

In 1947, BHC in planting water was also tried at the Chatham laboratory for wireworm control. Applied on the soil surface around the tobacco plants, this material retarded growth and did not afford satisfactory protection. In 1949, chlordane in planting water was tried in southwestern Ontario with moderate success.

This paper is a report on experiments with planting-water treatments in the period 1950 to 1952.

#### METHODS AND MATERIALS

In 1950, the following wettable powders were compared in planting-water treatments for control of wireworms attacking burley tobacco: lindane, 1 oz. per acre; aldrin, 1 lb.; chlordane,  $\frac{1}{2}$ ,  $\frac{3}{4}$ , 1, and 2 lb.; parathion,  $\frac{1}{2}$  lb.; check, planting water only. Ten ounces of liquid were applied, on the soil surface, at the base of each plant. This high rate of application was made to ensure that the planting water reached the roots of the transplants.

In 1951, the only insecticide used on burley tobacco was lindane. Treatments were applied with a mechanical tobacco transplanter at  $\frac{1}{4}$  and  $\frac{1}{2}$  oz. per 40-gal. barrel of planting water, or 1 and 2 oz. per acre. In addition, dipping the roots and underground parts of the stem of the tobacco plant in lindane suspensions at rates equivalent to 8 and 24 oz. per acre was tried. The lindane planting-water treatment was tried on a field scale for the first time on flue-cured tobacco near Dresden, Ont.

In 1952, experimental work was conducted on both flue-cured and burley tobaccos. The flue-cured tobacco experiment was at Port Stanley, Ont. Lindane in the planting water at  $\frac{1}{4}$  oz. per 40-gal. barrel was compared with a lindane seed dressing on fall rye, applied in the fall of 1950 for control of the wireworms. In the burley tobacco experiment at Highgate, Ont., lindane at  $\frac{1}{4}$  oz., heptachlor at 2 oz., and chlordane at 4 oz. per 40-gal. barrel of planting water were compared. Field demonstrations of lindane in the planting water on burley and flue-cured tobaccos were observed in a number of growing areas.

In 1950, wireworm counts were made in each plot before and after treatment by standard soil sifting methods. Wireworm damage was assessed by examining all dead or dying plants 1 and 2 weeks after transplanting. The number of plants harvested in each plot was recorded. Yields were taken by stripping and weighing the cured leaf from 50 tobacco plants chosen at random in each plot. The records taken in 1951 were the same as those taken in 1950, with the addition of plant growth measurements made approximately 1 month after transplanting. In 1952, in the flue-cured tobacco experiment, yields were not taken. In the burley tobacco experiment, green-weight records were used instead of yields of cured leaf.

Periodic examinations were made in 1951 on the field demonstration of lindane in the planting water on flue-cured tobacco, and in 1952 on both burley and flue-cured tobaccos.

### RESULTS AND DISCUSSION

Records of plant injury by wireworms were largely used as an index of effectiveness of the treatments. Crop growth and wireworm populations are not discussed in detail at this time.

In Table 1, the percentages of burley and flue-cured tobacco plants showing wireworm injury are given for the various treatments for 1950, 1951, and 1952.

TABLE 1  
PERCENTAGE OF BURLEY AND FLUE-CURED TOBACCO PLANTS SHOWING  
WIREWORM INJURY IN 1950, 1951, and 1952

Year	Treatment	Amount per acre	Method of application	Percentage of plants show- ing wireworm injury
<b>Burley</b>				
1950	Lindane	1 oz.		9.4
	Aldrin	1 lb.		16.9
	Chlordane	½ oz.	Planting	22.3
	Chlordane	¾ lb.	water ap-	16.5
	Chlordane	1 lb.	plied to	15.2
	Chlordane	2 lb.	soil surface	21.5
	Parathion	½ lb.		17.9
	Check			33.5
1951	Lindane	1 oz. }	Planting	8.0
	Lindane	2 oz. }	water	8.0
	Lindane	8 oz. }	Dipping	6.25
	Lindane	24 oz. }	treatment	8.75
	Check			43.25
1952	Lindane	1 oz.		5.0
	Chlordane	1 lb.	Planting	12.5
	Heptachlor	½ lb.	water	7.25
	Check			22.0
<b>Flue-cured</b>				
1952	Lindane	1 oz.	Seed treatment	3.5
	Lindane	1 oz.	Planting water	0.25
	Check			5.75

The lindane planting-water treatment afforded good protection from the wireworms for the 3 years it has been under trial. Aldrin, chlordane, parathion, and heptachlor were inferior to lindane whenever used. Although good protection was obtained by dipping the roots and underground parts of the stem of the tobacco plant, it is doubtful whether this method of control would find favour with tobacco growers. The plants are wet when planted, and are disagreeable to handle. The lindane seed treatment on fall rye, preceding tobacco in the standard rye-tobacco rotation, reduced the damage slightly. This treatment may have a place in wireworm control after the population has been reduced by other means.



The lindane planting-water treatment at  $\frac{1}{4}$  oz. per 40-gal. barrel of planting water has had no visible adverse effect on the growth or yield of the tobacco. In fact, especially in flue-cured tobacco in 1952, a marked increase in growth was noted in the plots treated with lindane in the planting water. The increase in growth was greater than the reduction in the wireworm activity seemed to warrant. The treatment may have had some direct or indirect stimulating effect on the growth of the tobacco. Increasing the lindane to  $\frac{1}{2}$  oz. caused slight distortion of the tobacco plants. However, the plants recovered and the yield records indicated normal growth. This was also noticed when the tobacco plants were dipped in the lindane suspension at the higher rate. Aldrin, parathion, and heptachlor had no visible effect on the growth of the tobacco plants. In 1950, all rates of chlordane appeared to reduce the yield. However, in 1952 the tobacco plants treated with chlordane were comparable with those in the check.

The reduction in the wireworm population has not been greater than 25 per cent with the lindane planting-water treatments. Increasing the rate of application did not give a corresponding decrease in the wireworm population, nor did dipping the roots and underground stems of the tobacco plants in a lindane suspension. The other organic insecticides were inferior to lindane. In 1952, the reduction in the wireworm population was not great. Hot, dry weather, when the tobacco was transplanted, no doubt reduced the activity of the wireworms so that fewer wireworms came in contact with the insecticides.

In the field trial of lindane in the planting water in 1951, the wireworm damaged plants were reduced approximately 90 per cent. In 1952, in the field trials the check rows were inferior, and there was some evidence in flue-cured tobacco that the treated rows ripened earlier. This further suggests the possibility of a stimulating effect from lindane.

The lindane planting-water treatment is economical and requires a minimum of effort for application. So far as can be determined in the time it has been in use, it does not constitute a health hazard to operator or consumer, nor does it appear to create a residue problem in plant or soil.

### CONCLUSIONS

The results of 3 years' experimental work have shown that lindane in the tobacco planting water will satisfactorily protect tobacco transplants from wireworms. At 1 oz. of 25 per cent wettable powder per 40-gal. barrel of planting water, there was no phytotoxic effect on tobacco; in some cases, an increase in plant growth was apparent. The treatment may have to be used every year that tobacco is grown in infested fields as the reduction in the wireworm population has never been greater than 25 per cent.

Aldrin, parathion, heptachlor, and chlordane, tested in the planting water, were inferior to lindane. There was some indication that chlordane adversely affected the growth of the tobacco.

Lindane seed treatments on fall rye may have a place in wireworm control where the rye-tobacco rotation is used. This treatment alone is apparently not sufficient, but may be used in preventing wireworm populations from increasing in fields in which they have been reduced by more effective treatments.

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NOTE ON CONTROL OF FLEA BEETLES ON TOMATOES BY  
PRE-TRANSPLANTING TREATMENTS  
(COLEOPTERA: CHRYSOMELIDAE)

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In Ontario, flea beetles, of which *Epitrix cucumeris* (Harr.) is the most abundant species, commonly attack tomato plants soon after they are set out in the field. The plants frequently require more time to become established when injured by flea beetles, and as sprays are seldom applied until the damage is noticeable they are expensive and usually too late to be effective. Though DDT has been generally recommended for flea beetle control, it has been the general impression of entomologists that it would harm young tomato plants. In 1952, experiments were conducted on treating the plants by adding DDT to the last fungicide spray applied when the plants were still in the flats.

Eight growers on farms throughout Prince Edward County co-operated by providing test fields. Each grower was free to choose the source and variety of his plants, using only one variety from only one source. All plants were locally grown except for one farm where their source was Georgia.

One ounce of 50 per cent wettable DDT and three-quarters of an ounce of ziram (1 oz. of Zerlate, Canadian Industries Limited, Toronto) were added to 2½ gallons of water for a tankful of spray. The spray was applied with compressed-air, cylindrical hand sprayers, of the shoulder-strap type. Flats were spaced eight inches apart to facilitate spraying from all sides. Both the lower and upper surfaces of the leaves were thoroughly covered with spray. A tankful was made up and applied in half an hour, the materials costing 6½ cents. On an average this was sufficient to spray plants for two acres. The plants that came in bundles from Georgia were loosened and dipped in the mixture; this was equally as fast as using the spray.

Treated and untreated plants were transplanted between May 28 and June 5 in contiguous, equal solid blocks. Replacements, including those for most of the plants destroyed by cutworms, were made within a few days after transplanting, and these received the same treatment as the original plants; otherwise the growers followed their normal cultural procedures, including the use of field sprays. None applied field sprays within three weeks after planting. Any sprays that were applied contained fungicide only.

Records were taken on flea beetle injury, plant heights, and yields. Two weeks after planting, the plants were examined for injury in straight lines across equal numbers of treated and untreated rows. Damage per compound leaf was weighted as follows: slight damage, one to 20 feeding pits: one point; moderate damage, 21 to 100 pits: 5 points; severe damage, more than 100 pits: 15 points. Plant heights were recorded 25 and 44 days after planting. In each of seven fields, three eight-plant plots in the treated and three in the untreated areas were harvested on each of five dates between August 19 and September 20 (one field that had grown to weeds was not harvested); the plots consisted of two adjacent rows of four plants each. Therefore, there were 210 yield records for the 42 plots.

In the treated areas of the fields 30 per cent fewer plants and 33 per cent fewer leaves were attacked by flea beetles. The reductions in injury in the various fields ranged from 54 to 93 per cent, the average being 72 per cent. Analysis of variance showed that these three differences were significant at the one per cent level.

Though there was a trend toward tallness of treated plants, the spray had no significant effect on plant height and no appreciable effect on growth was observed.

The average yields of treated and untreated plants were 8.97 and 6.39 tons per acre respectively, and the standard error of the means was  $\pm 0.87$ . This difference was significant at the five per cent level.

It was noted, also, that in two fields cutworms destroyed a number of the transplants in the untreated areas but none in the treated.

Though the results varied considerably in the different fields, an expenditure of less than 25 cents per acre for labour and materials gave an average gain of \$90.00 per acre, estimated at current prices and grading levels. Further, the spray caused no damage to the plants. On the basis of one year's tests, spraying with DDT before transplanting seems warranted as a routine measure for the control of flea beetles on tomatoes.



## THE POST-HARVEST CONTROL OF *MICCOTROGUS PICIROSTRIS* (F.) (COLEOPTERA: CURCULIONIDAE) IN ALSIKE FIELDS, 1949-1952<sup>1</sup>

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*Miccotrogus* (= *Tychius*) *picrostris* (F.), tentatively named the clover seed weevil, is undoubtedly the principal insect pest of the alsike clover seed crop in southern Ontario. Ladino and white Dutch clovers are host plants also. The present extent of our knowledge indicates that there is only one generation a year although a partial second generation possibly may develop in either of the other hosts.

Pielou (1950) and Heming (1952) have reported on the control of the insect in the growing alsike crop. In 1949, investigations were begun on the possible use of cultural practices immediately after crop harvest to control weevils in infested alsike seed fields. When the crop is mature, most of the weevils are present in the soil as larvae, prepupae, pupae, or new adults within  $\frac{1}{4}$  to  $\frac{1}{2}$  inch of the surface and are particularly vulnerable to attack. At first, cultural treatments alone were tested. These afforded some measure of control but later the application of insecticides, with or without disturbing the soil, proved more effective in reducing weevil populations in the soil.

**EQUIPMENT** — The farm machinery necessary for the experiments involving cultural controls was loaned by the farm owners or their neighbours or provided by the Department of Agricultural Engineering of the Ontario Agricultural College. Spray applications were made with a tractor-drawn power sprayer (Farquhar Iron Age) equipped with a  $1\frac{3}{4}$  h.p. engine, a 100-gallon tank, and a 15- or 18-foot, 11- or 12-nozzle boom, adjustable for height. A pressure of approximately 100 lbs. was used in all tests.

**METHODS** — *Bailey field*, 1949. — A 12-acre field of alsike on heavy Clyde clay near Chatham, Ontario, was found to be severely infested with weevils at the time when the clover was flowering and setting seed. On July 4, it was mowed. Because of hot dry weather the crop was ready to be threshed on July 6. Threshing had to be delayed until July 11; the cultural control experiment also was postponed. Counts made on 20 one square-foot plots on July 11 showed that weevils of the new generation were beginning to emerge in numbers from the soil. An average of 8.3 weevils per square foot were taken as they crawled about on the soil surface.

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To test certain cultural treatments three linear blocks (200 feet by 12 feet), divided into 8 small (25 feet x 12 feet) plots each, were laid out across the field 20 feet apart. This arrangement provided 4 treatment replications and facilitated the use of regular farm equipment. On July 12 the following treatments were applied:

1. Ploughed, 4 inches
2. Ploughed, 4 inches; disked and rolled
3. Ploughed, 6 inches
4. Ploughed, 6 inches; disked and rolled
5. Check, no treatment.

In order to determine what effect the treatments might have had on the life history stages in the soil, weevil emergence from the plots was recorded daily from July 13 to August 3. Emergence data were obtained by placing cages over the soil in each plot. Cages consisted of inverted 2½-gallon galvanized sap pails with the rims sunk and tamped firmly into the soil to a depth of 2 inches (Fig. 1). To collect newly emerged weevils each pail was fitted near the upturned bottom rim with a glass vial inserted snugly into a round opening. The positively phototropic weevils entered the vials soon after emergence and were recorded readily. In Fig. 1 the arrangement of the experimental area and the placement of the emergence cages, are shown.



Fig. 1. Arrangement of blocks and plots in experimental area and method of placing cages for weevil emergence. Bailey farm, 1949.

*Porter field, 1950:* This was a long, narrow, 6½-acre strip of alsike on Oneida clay loam in Haldimand County. Earlier in the season it had been used for an experiment on the control of *Miccotrogus* in the growing alsike. When the crop was harvested, the untreated check areas, comprising about 2½ acres, were used for post-harvest control tests. Twenty ⅛-acre plots of 5 treatments replicated 4 times were laid out. The following treatments were applied on July 28 and 29:

1. Rotary plowed, 3-4 inches
2. Ploughed, 5 inches; cultipacked
3. Ploughed, 5 inches; cultipacked; double-disked; cultipacked

4. Check, no treatment
5. Lindane<sup>1</sup> 25% w.p., sprayed on soil surface at the rate of 0.25 lb. actual toxicant per acre in 80 gallons of water; double-disked.

Sixteen emergence cages, similar to those used in the preceding experiment, were placed on each plot; 8 where windrows had been lying and 8 between the windrows. This arrangement was considered advisable as the crop had been lying in the windrow for 7-9 days prior to pick-up combining and many mature larvae had dropped from the cut alsike and entered the soil to pupate. Weevil emergence data were recorded daily from July 30 to August 24. The last observations were made on August 30 to record any late emergences. Undoubtedly many new-generation weevils emerged prior to the application of treatments because of the delay in completing the harvest but this should not alter the validity of the results obtained.

*Laboratory studies, Methods and results, 1951:* In the Chatham laboratory an experiment was set up early in July to determine the effectiveness of various insecticides in the control of *Miccotrogus* larvae and pupae in the soil. Mature larvae were collected from alsike heads from the A. Pepper farm near Merlin, Ontario. Earth was obtained from the same field and dried at 140°F. The insecticides, in the form of stock solutions, were added to enough water to bring the moisture content of the soil samples to 13 per cent. The treated soil samples were put into pint "sealright" containers, to a depth of 3 inches. Ten vigorous larvae were placed in each container. In order to check the daily weevil emergence in the covered containers, a glass vial was inserted into the side of each. The following treatments were replicated 5 times (Table 1):

Table 1  
LABORATORY INSECTICIDAL TREATMENTS AND EMERGENCE OF  
*MICCOTROGUS* ADULTS

<i>Insecticide</i>	<i>Amt. actual toxicant per acre</i>	<i>Per cent weevil emergence</i>
DDT	1.2 lb.	38
50% w.p.	2.4	36
	5.0	24
Chlordane	.5	16
40% w.p.	1.0	16
	2.0	10
Aldrin	3.0	0
25% w.p.	5.0	0
	7.0	0
Lindane	2.0	22
25% w.p.	4.0	12
	8.0	2
Check	—	72

The first emergence for all except the aldrin-treated replicates, was recorded 17 days after the larvae were placed in the containers. Twice during the period of the experiment it was necessary to add water to each container. In each case this increased the number of weevils which emerged the following day.

From Table I, it is readily evident that aldrin at the concentrations tested was the most effective insecticide and probably smaller amounts would have been satisfactory.

<sup>1</sup>Donated by Dow Chemical of Canada Ltd.

*Fallis field*, 1951: This was a small volunteer stand of alsike on Haldimand clay in Haldimand County. The crop was uneven and patchy. The weevil population based on counts obtained from net sweeps was much lower than at the Porter farm the preceding year. Again weather delayed harvesting at least a week and in order to set up the experiment as early as possible the raked swaths were carefully forked off the test area. Twenty 1/50-acre plots of 5 treatments replicated 4 times were laid out and on July 27-28 the following treatments were applied:

1. Lindane<sup>1,2</sup>, 25% w.p., 0.25 lb. actual toxicant per acre; double-disked
2. Check, no treatment
3. Ploughed, 5 inches; cultipacked; double-disked; cultipacked
4. Ploughed, 5 inches; cultipacked
5. Dieldrin<sup>1,3</sup> (Dieldrex 15), 2.0 lbs. actual toxicant per acre; double-disked.

Sixteen emergence cages, as described earlier, were placed on each plot. Daily weevil emergence records were obtained from July 28 through August 29.

*Robinson field*, 1952: The study area was part of an 8-acre field of uniform alsike in bottom land (Peel clay) in Peel County. Harvesting of the unsprayed crop was delayed beyond the normal time because of the unusual amount of green foliage present. Part of the field was cut July 8, using a binder with a buncher attachment. Wet weather delayed the cutting of the remainder until July 11. Rain delayed threshing until July 16 and 17. Twenty-four 1/40-acre randomized plots, comprising 6 treatments, each of which was replicated 4 times, were laid out. To permit easy movement of the spray machine, adjacent blocks of plots were separated by a turning area 8 yards wide. The following insecticidal and cultural treatments were applied on July 17-18:

1. Ploughed, 5 inches; cultipacked
2. Lindane<sup>1,2</sup>, 25% w.p., 0.25 lb. actual toxicant per acre
3. Dieldrin<sup>1,3</sup> (Dieldrex 15), 1.5 lb. actual toxicant per acre
4. Aldrin<sup>1,3</sup> (20% emulsifiable concentrate), 1.5 lb. actual toxicant per acre
5. Check, untreated
6. Heptachlor<sup>1,4</sup> (2E emulsifiable concentrate), 0.75 lb. actual toxicant per acre.

Thirteen emergence cages were placed on each plot. Of the 52 cages on the plots of each treatment, 26 were placed in soil on which alsike bunches had lain and 26 in spaces between. Daily weevil emergence records were taken from July 19 through August 18, when emergence seemed to be complete.

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<sup>1</sup>Sprayed on soil surface in the equivalent of 80 gallons of water per acre.

<sup>2</sup>Donated by Dow Chemical Co. of Canada Ltd.

<sup>3</sup>Donated by Shell Oil Company of Canada Ltd.

<sup>4</sup>Donated by Velsicol Corporation.



**RESULTS AND DISCUSSION.** — In Fig. 2, the results of the field experiments conducted during 1949-52 are shown. The early work on the Bailey farm (1949) showed that regular field culture by ploughing alone or ploughing followed by disking and rolling, soon after harvest, reduced weevil populations in the soil from 36 to 55 per cent. While not satisfactory from a practical standpoint, the results warranted some further work under more favourable conditions of harvest and treatment timing.

At the Porter farm in 1950, the treatments reduced weevil emergence from 45.6 to 73.5 per cent. All reductions were highly significant. Lindane followed by disking was the most effective treatment reducing emergence 73.5 per cent. This reduction was significantly greater than that of any other treatments. There were no statistical differences in effectiveness between the three cultural controls tested.

The delay in application of treatments for a week or more after the crop was mowed and windrowed permitted considerable weevil emergence to take place. Also, as a result of the delay, greater numbers of *Miccotrogus* in the soil were pupae or newly transformed adults in firm earthen cells and thus, perhaps, less susceptible than larvae to the damaging effects of the cultural treatments.

In 1951 at the Fallis farm, a dieldrin spray was substituted for the rototiller treatment otherwise the programme was similar to that of 1950 except that the weevil population was considerably smaller. The ploughed-cultipacked plots showed a much greater weevil reduction than similar treatments gave either in 1950 or 1952. The ploughed-cultipacked-disked-cultipacked plots, on the other hand, were much less effective here than at the Porter farm. An explanation of these differences may reside in the soil types, moisture content, the weather following treatment or the irregularities of the alsike stand. Both insecticides effected excellent control. Because of the nature of the soil the double disking which followed the application of each insecticide failed to disturb the soil surface to any appreciable extent.

At the Robinson farm in 1952, all of the insecticides tested significantly reduced (at the 1 per cent level) the emergence of *Miccotrogus* weevils. There were no significant differences in effectiveness between them and all effected a nearly complete control. The one cultural control tested (ploughing and cultipacking) also produced a highly significant reduction in weevil emergence but it did not compare with any of the insecticides.

An evaluation of the results of 4 seasons of post-harvest control experiments indicates that none of the cultural methods tested effected an adequate control. However, if an alsike seed crop was harvested at the earliest possible time (which seldom is done) and the land was immediately ploughed and cultipacked, at least a 50 per cent control could be expected without any extra cost, as the operations are those normally followed, except for timing, in preparing the soil for the following crop.

At the present time the aldrin and dieldrin emulsifiables, at the rates used in these experiments, are too costly for forage and legume seed insect control. While the results suggest that smaller quantities of these insecticides might be effective, a considerable reduction in price would be necessary before growers would use them. Lindane and heptachlor are cheaper—under \$2.50 per acre exclusive of application costs—and the amount of heptachlor possibly can be reduced somewhat. The aldrin and heptachlor were tested for one season only and further work should be done. At the present time, only lindane of the insecticides used in the field tests is registered in Canada for legume seed insect control.

Whether a grower will be willing to treat a field of alsike after the crop is off, in order to prevent or reduce damage the following year is a question. In areas where some acreage is devoted to seed production, it would be necessary for all growers to practise either post-harvest control or to treat the growing crop with DDT, as individual post-harvest effort would be largely wasted because the weevils have well-developed flight powers. If either control is followed and the treatment is accurately timed, satisfactory crops of alsike seed should once again be obtainable in spite of the fact that other host plants might serve as reservoirs.



Ordinarily, pollination is not a problem with alsike, although the placing of honeybee colonies in close proximity to the seed field would insure adequate seed set.

**SUMMARY.**—In Southern Ontario when an alsike seed crop is ready for harvest and for a short time thereafter, *Miccotrogus picrostris*, the principal insect pest, is present in the surface  $\frac{1}{2}$  inch of the soil as mature larvae, prepupae, pupae, or newly transformed weevils.

Cultural practices such as: ploughing; ploughing, disking and rolling; ploughing and cultipacking; ploughing, cultipacking, double-disking and cultipacking; and rototilling, reduced by 36 to 73 per cent the numbers of new adults which emerged from the soil. Ploughing followed by cultipacking immediately after harvest was the most satisfactory of these cultural procedures in clay and clay-loam soils.

Laboratory studies on the efficacy of the soil insecticides—wetttable powders of DDT, aldrin chlordane, lindane—established that aldrin at 3 lbs. of actual toxicant per acre killed all stages in the soil. Field tests indicated that lower rates of aldrin are almost as effective.

Field experiments with soil insecticides—lindane, w.p.; aldrin, dieldrin, and heptachlor emulsifiable concentrates—showed, that at the following rates of actual toxicant per acre—0.25 lb.; 1.5 lb.; 1.5 lb.; and .75 lb. respectively—excellent control was obtained. It is possible that the rates for aldrin and dieldrin could be reduced without reducing their efficiency appreciably. At the present time only lindane of these insecticides is registered in Canada for forage or legume seed insect control.

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**Fig. 2.** Effect of post-harvest cultural and insecticidal treatments on emergence of adults of *Miccotrogus* (= *Tychius*) *picrostris* from soil of alsike fields.

- A. Ploughed, 4 inches.
- B. Ploughed, 6 inches.
- C. Check-no treatment.
- D. Ploughed, 4 inches; disked and rolled.
- E. Ploughed, 6 inches; disked and rolled.
- F. Rototilled.
- G. Ploughed, 5 inches; cultipacked.
- H. Ploughed, 5 inches; cultipacked; double-disked; cultipacked.
- I. Lindane, 0.25 lb./ac.
- J. Dieldrin, 2 lb./ac.
- K. Aldrin, 1.5 lb./ac.
- L. Heptachlor, .75 lb./ac.



## SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURRENCES, AND DAMAGE IN CANADA IN 1952<sup>1</sup>

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This summary of insect conditions has been prepared from regional reports submitted by officers of the Division of Entomology, provincial entomologists, officers of the Division of Plant Protection, and university professors. In general, common names used are from the 1950 revision of the list approved by the American Association of Economic Entomologists. Common names other than these are accompanied by technical names. To avoid unnecessary duplication, forest insect conditions are not included, this insect group being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey*, published by the Division of Forest Biology, Canada Department of Agriculture.

The summary of weather conditions was compiled from data in reports submitted by officers of the Division of Entomology, and in seasonal federal and provincial crop reports. The crop production summary was taken from the "November Estimate of Production of Principal Field Crops, 1952", Dominion Bureau of Statistics, with data revised to agree with the Bureau's "Revised Estimate", Feb. 20, 1953. Data for Newfoundland were not available.

### SUMMARY OF WEATHER CONDITIONS IN CANADA IN 1952

In British Columbia, precipitation was well below normal in the interior, especially during the spring and autumn; it was low also in southern areas and on Vancouver Island until June, and even later in the Peace River district. Rains were general during July, and hail caused some damage to grains and fruit at Armstrong and Vernon. The weather was generally dry through most of August, but in the Peace River district frequent showers delayed the ripening of grain. Temperatures were below average except in April and October, and in the interior sunshine exceeded the long-term average. Growth, although somewhat retarded during the early part of the summer, extended well into the autumn.

In the Prairie Provinces, spring was early in 1952, the month of April being one of the warmest and driest on record. Such conditions were ideal for harvesting the large acreage of the 1951 crop left in the field over winter, and suitable for early seeding. Moisture reserves were well above normal in Alberta and Saskatchewan, and above average in Manitoba. Spring precipitation continued to be well below normal until the latter part of May, permitting completion of seeding and threshing in most areas. During the early part of May crops in southern Manitoba began to deteriorate from drought and some soil drifting occurred; later in the month general rains in the prairie area relieved the situation; crops recovered appreciably but hay was short. Grains and sugar beets in the dry areas of southern Manitoba and extreme southeastern Saskatchewan were considerably damaged by cutworms; some wireworm damage occurred also. Timely rains throughout the growing season resulted in fair crop recovery in dry districts, and maintained good growth generally, to produce the largest grain crop in the history of the West. Weed growth, too, particularly wild oats, was heavy. Hail losses occurred in all three provinces but were, on the whole, moderate. Insect damage, in general, was slight, partly because of weather conditions adverse to insect development during the latter part of the 1951 season, and nearly ideal conditions for plant growth in 1952; the grasshopper population was one of the smallest on record. Weather conditions during the early part of the harvest season were unfavourable in many districts, but improved later to permit completion of this activity. General, severe frosts did not occur until October.

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In Ontario and Quebec, dry, warm weather during the last three weeks of April and dry, cool conditions during the first ten days of May permitted early completion of seeding in most areas. Winter-killing of fall wheat averaged only about eight per cent in Ontario, and hay survived well except in several eastern counties. Frequent rains from May 11 to mid-June provided moisture for seed germination and continued growth but cool weather retarded the latter. Excessive moisture in parts of eastern and northern Ontario and certain areas of Quebec, including the Abitibi and Temiscaming districts, caused some crop damage, retarded seeding, and later caused considerable spoilage of a heavy crop of hay. The early-season dry weather persisted until July in extreme southern areas of Ontario, resulting in poor pastures, reduced yields of wheat, hay, and beans, and considerable cutworm damage to tobacco and tomato crops. Very hot weather in July caused spring grains to mature much earlier than usual in both provinces. Rains in late July and early August helped to fill out grain in central and south-western Ontario, but drought conditions persisted in Quebec, in the Abitibi and Temiscaming areas, during this period. Weather conditions were very favourable to growth of all crops during August and September in Ontario, but were somewhat less favourable in Quebec. Harvest operations were hampered by frequent rains in many areas but pastures benefitted. September frosts caused some damage to the tobacco crop near Montreal. Crop yields, in general, were below those of 1951 in both provinces.

Following a winter of unusually heavy snowfall, spring came fairly early in the Gulf of St. Lawrence region. The winter in Newfoundland was unusually mild and favourable to insect survival. Little rain fell in April and seeding was well started in New Brunswick by the end of the month, but cold, wet weather during May and June delayed the completion of field work in many districts. Growth was generally retarded and some moisture damage occurred in low areas. Apple blossom was delayed to the extent that, at least in Nova Scotia, it escaped frost damage completely, but the weather was not favourable to pollination. Higher temperatures toward the end of June were accompanied by good growth, notably of hay and pasture. July was unusually hot and dry, adversely affecting pasture, potatoes, and grain, particularly in New Brunswick. Good rains in August relieved drought conditions in all areas. Crop yields, particularly of early-planted grain, were fair to good. Late grain was light, notably in New Brunswick. Yields in general were below those of 1951, and the apple crop was light, but potatoes yielded better than expected. No serious outbreaks of insects were reported during the growing season.

#### CROP PRODUCTION SUMMARY FOR CANADA, 1952

The estimated total crop acreage of field crops in Canada in 1952 was 61,812,000, compared with 60,868,000 in 1951. The latter figure is based on the 1951 census. Canadian farmers in 1952 harvested record crops of wheat, barley, and soybeans; near-record crops of rye, sugar beets, and shelled corn; and above-average outturns of most other field crops. In sharp contrast with 1951, harvesting conditions in Western Canada were almost ideal, enabling farmers in the Prairie Provinces to harvest a combined total of 1.3 billion bushels of wheat, oats, barley, rye, and flaxseed. Elsewhere, conditions were almost without exception favourable for harvesting potatoes, sugar beets, fodder corn, and other late crops. On a regional basis, the greatest increases over 1951 production occurred in Western Canada. The only crops in the four western provinces for which decreases from 1951 were indicated were sunflower seed, tame hay, and sugar beets in Manitoba; mixed grains, dry peas, and potatoes in Saskatchewan; oats and mixed grains in Alberta; and wheat, dry beans, and field roots in British Columbia. In Eastern Canada, on the other hand, excepting potatoes and tame hay, yields of most crops were below those of 1951.

**WHEAT.**—Canada's 1952 wheat crop, estimated at the unprecedented level of 688 million bushels, exceeded by 121 million bushels the previous record of 567 million set in 1928. Although the seeded area of 26.0 million acres was almost 10 per cent below the record 28.7 million seeded in 1940, the average yield of 26.5 bushels per acre exceeded by half a bushel the record set in 1951. In the Prairie Provinces the wheat crop was placed at 664 million bushels, compared with 529 million in 1951 and the previous record of 545 million harvested in 1928.

**OATS FOR GRAIN.**—Production of oats for grain in 1952 was estimated at 466 million bushels, 22 million less than in 1951 and about 29 per cent less than the record 652 million harvested in 1942. The decrease from 1951 was attributed to smaller seeded acreages since the average yield of 42.1 bushels per acre was somewhat above the 1951 level of 41.0 bushels. Production was down in all provinces except Manitoba, Saskatchewan, and British Columbia.

**BARLEY.**—The 1952 barley crop, estimated at a record 291 million bushels, was 46 million greater than in 1951 and 32 million above the previous record crop harvested in 1942. Barley production was below the 1951 levels in all eastern provinces, but sharp increases occurred in the four western provinces. In Alberta a new record of 118 million bushels was established, in Saskatchewan the record of 92 million set in 1942 was equalled, and in Manitoba the 1952 crop of 71 million bushels was second only to the 74 million harvested in 1942.

**RYE.**—The combined yield of fall and spring rye was placed at 24.6 million bushels, the fourth highest on record. Larger acreages and average yields of both crops contributed to the increase of one-third over the 1951 crop of 17.6 million bushels. Saskatchewan was the major producing area for this crop, accounting for 47 per cent of the 14.8 million bushels of fall rye and 72 per cent of the 9.8 million bushels of spring rye grown in Canada in 1952.

**OILSEEDS.**—Excepting sunflower seed, the 1952 production of oilseeds for which estimates were available was well above the 1951 level. Production of flaxseed was estimated at almost 13 million bushels as against 9.9 million in 1951. All but one million bushels was grown in the Prairie Provinces, with Manitoba's 5.7 million bushels accounting for 44 per cent of the total. Soybean production, currently confined to Ontario, set a new record of 4.1 million bushels, some 500,000 bushels greater than the 1951 crop. Rapeseed production, estimated at 15.9 million pounds, was double the 1951 outturn. The increase resulted from greater acreage in Saskatchewan and the introduction of this crop into Manitoba, the first time in some years that significant quantities had been grown outside Saskatchewan. The Saskatchewan crop was estimated at 11.4 million pounds and that in Manitoba at 4.5 million. Production of sunflower seed, currently confined to Manitoba, continued the downward trend of the past few years. The 1952 crop was estimated at 2.3 million pounds as against 6.4 million in 1951.

**MIXED GRAINS.**—Production of mixed grains, grown chiefly in Eastern Canada, was estimated at 63.2 million bushels as against 68.5 million in 1951. The outturn in Ontario, the major producing area, was placed at 48.0 million bushels, or about 76 per cent of the total. The 1952 all-Canada crop was harvested from a seeded area of 1.6 million acres averaging 40.0 bushels per acre.

**DRY BEANS AND PEAS.**—Production of dry beans was placed at 1,298,000 bushels as against 1,233,000 in 1951, and of dry peas at 888,500 bushels as against 745,000 bushels. All but 21,000 bushels of the dry bean crop was grown in Ontario. Although production of dry peas was more widespread, slightly more than half of the crop was grown in Manitoba, with Ontario, Alberta, and Quebec accounting for most of the balance.

**SHELLED CORN.**—Production of shelled corn was estimated at 19.7 million bushels, the largest since 1908 and 3.7 million greater than in 1951. Excepting an estimated 552,000 bushels in Manitoba, all of the shelled corn crop was grown in Ontario.

**POTATOES.**—As a result of moderate acreage increases in all provinces except Quebec, Saskatchewan, and Alberta, and yield increases in all provinces, the 1952 potato crop was placed, *on the basis of field-run yields*, at 58.9 million bushels as against 48.4 million in 1951. The average yield of 200 bushels per acre was the highest on record, but the area, estimated at 294,000 acres, was only 3 per cent greater than the 1951 low level of 285,000 acres.

**SUGAR BEETS.**—Production of sugar beets in the four beet-growing provinces was placed at a near-record one million tons, slightly above the 1951 total. Increases in both acreage and yield in Alberta, where a record crop of 480,000 tons was produced, more than offset lower outturns in Quebec, Ontario, and Manitoba.



**FORAGE CROPS.**—The total production of tame hay (including clover and alfalfa) was estimated at 19.1 million tons, compared with 19.5 million in 1951. A decrease of 1.2 million tons in Ontario, where nearly one-third of the crop was grown, together with a slight reduction in Manitoba, more than offset increases in all other provinces. Production of fodder corn at 3.8 million tons was somewhat greater than the 1951 crop of 3.6 million tons.

**OTHER CROPS.**—Production of buckwheat, which has been steadily declining in recent years, was placed at 2.7 million bushels as against 2.9 million in 1951. The crop of field roots (turnips, mangels, etc.) for livestock feed, excluding the Prairie Provinces, for which data were not available, was estimated at 14.1 million hundredweight, practically unchanged from 1951.

**HONEY.**—The honey yield in 1952 was 31,470,000 pounds, an average of 81 pounds per colony, compared with 40,909,000 pounds, an average of 101 pounds per colony, in 1951. The reduced yield may be accounted for in part by a reduction in the number of colonies, and in part by unfavourable weather conditions, mainly in the Prairie Provinces and Ontario.

#### NEW RECORDS OF INSECTS IN CANADA, 1952\*

A European tortricid, *Cacoecia oporana* L., was reared from larvae found feeding on snow-berry, *Symphoricarpos* sp., at Vancouver, B.C. The species was found on imported horse chestnut in a Toronto nursery in 1950, but, prior to the current record, had not been reared from any food plant in North America. (The Canadian Insect Pest Review 30: 267)

A flea beetle, *Psylliodes chrysocephala* (L.), occurred on rape at Topsail, near St. John's, Nfld., the first record in North America. (C.I.P.R. 30: 227)

A fly, *Musca autumnalis* Deg., was recorded for the first time in North America at Middleton, N.S., where it hibernated in tremendous numbers in the walls and interior of a church. (C.I.P.R. 30: 265)

The first North American record of the wood-infesting weevil *Pentarthrum huttoni* Woll. was published in 1952. The specimens had been taken from flooring in Quebec City, Que., in 1934. (Coleop. Bull. 6: 51-52, 1952)

A small, black moth, *Monopis ferruginella* Hbn., was found in large numbers in a dwelling at Vancouver, B.C., establishing the first North American record. (C.I.P.R. 30: 283)

The first record of the occurrence of the leafhopper *Erythroneura flammigera* (Geoffr.) in North America was published in 1952. The specimens were taken on cultivated cherry in Vancouver, B.C., in 1950. (C.I.P.R. 30: 268)

Another leafhopper, *Macropsis fuscula* Zett., not previously recorded in North America, is now known to be established on *Rubus* spp. in British Columbia.

An infestation of the cucujid *Oryzaephilus mercator* (Fauv.) was recorded, for the first time in Canada, at Ottawa, where it occurred on insect specimens in the National Collection. (C.I.P.R. 30: 281)

The curculionid *Apion longirostre* Oliv. occurred in considerable numbers on hollyhock in an area near Chatham, Ont. Previous North American records were from Georgia and from Ohio westward to Missouri, U.S.A. (C.I.P.R. 30: 242)

Larvae of the brown-headed ash sawfly, *Tomostethus multicinctus* (Roh.), were found feeding on an ash tree in London, Ont., the first record of this insect in Canada. (C.I.P.R. 30: 165-207)

The plant bug *Lygus nigrosignatus* Kgt. was reported to be abundant on cultivated mustard in the Coutts-Clarinda area of Alberta. It had not previously been reported in Canada. (C.I.P.R. 30: 270)

\*See The Canadian Insect Pest Review, Vol. 30, for further details.

The larger yellow ant, *Acanthomyops (Lasius) interjectus* (Mayr), was recorded, for the first time in Canada, at Hamilton, Ont., where it occurred in a dwelling. (C.I.P.R., 30 : 143)

The first Canadian record of the tick *Argas reflexus* F. was established when specimens were collected from a bird's nest at Summerland, B.C. (C.I.P.R. 30 : 143)

The tomato russet mite, *Vassates destructor* (Keif.), was recorded for the first time in Canada when it infested tomatoes in a greenhouse near Harrow, Ont.

A pyralid, *Aphomia gularis* Zell., found infesting corn flour and nuts in a warehouse and a bakery in Vancouver, B.C., previously had been recorded only at Montreal, Que., in 1934. (C.I.P.R. 30 : 266)

A tenebrionid, *Cynaesus angustus* Lec., previously recorded on only one occasion in Canada (Diana, Sask., 1944), was prevalent on cereal products in a mill at Medicine Hat, Alta. (C.I.P.R. 30 : 283)

The European wireworm *Agriotes obscurus* (L.), not known to occur in western North America except on Vancouver Island, was reported from Agassiz, B.C. (C.I.P.R. 30 : 269)

### GENERAL-FEEDING AND MISCELLANEOUS INSECTS

**BEET WEBWORM.**—Populations of this species were, in general, very small throughout the Prairie Provinces and larval feeding was confined chiefly to lamb's-quarters and russian thistle.

**BLISTER BEETLE.**—A severe infestation of *Epicauta oregona* Horn. destroyed 13,000 tomato plants and damaged many others at Ashcroft, B.C., in June. Larvae of *E. subglabra* (Fall) and *E. fabricii* (Lec.) were found feeding on grasshopper eggs in the area of the Red River Valley in which grasshoppers were abundant. *E. pennsylvanica* (Deg.) was reported from Fredericton, N.B., in appreciable numbers, and normal numbers of *E. murina* (Lec.) were present in northern Nova Scotia.

**CRICKETS.**—The usual autumnal invasion of gardens and homes by the field cricket occurred in the Vernon, B.C., area, and a moderate, local infestation of the coulee cricket, *Peranabrus scabricollis* (Thos.), developed on range land near Vernon. In Manitoba both the field cricket and the Mormon cricket were generally less abundant than in 1951, and in eastern Ontario the field cricket was reported to be present in considerably above average numbers.

**CUTWORMS.**—In British Columbia, very large numbers of the dark-sided cutworm caused serious damage to seedlings and transplants on the Saanich Peninsula, this being by far the worst outbreak of cutworms ever recorded on Vancouver Island. An infestation of *Autographa californica* (Speyer), although light, caused considerable loss of young head lettuce near Victoria. Cutworms were numerous in the lower Fraser Valley, where the variegated cutworm so damaged several fields of corn that re-seeding was necessary, and caused considerable injury to greenhouse tomatoes at Nanoose Bay; *Apamea amputatrix* (Fitch) [= *Septis arctica* (Fr.)], *Agroperina cogitata* Sm., and *Leucania farcta roseola* (Sm.) all contributed to injury in sod. The black army cutworm was present in asparagus plantings at Kamloops and caused severe damage to cereal and forage crops at Prince George. As this outbreak subsided it was succeeded by severe infestations of the red-backed cutworm. For the third year in succession large populations of cutworms were very injurious to small fruit trees in the Okanagan and Kootenay valleys.

In Alberta, infestation was generally light and confined to localized areas. Some crop losses near the Acadia Valley in east-central Alberta were the only ones reported. However, an increase in infestation in southeastern and east-central areas was forecast for 1953.

In Saskatchewan, infestations of the pale western cutworm were greatly reduced in comparison with those of 1950 and 1951, and severe damage occurred only in a few localized areas. Largest numbers occurred in the area about Rosetown, the infestation extending in a narrow strip from Mildred through Rosetown to Stranraer. Larvae were found in about half of the

cropped fields but damage was observed in only a few of them. Elsewhere this cutworm was scarce, only very light damage being reported from the Totnes, Elrose, White Bear, Cabri, Hazlet, Leader, Hanley, Girvin, Saskatoon, Floral, Dundurn, and Prud'homme districts. No infestations were reported in the Kamsack-Wroxton area in eastern Saskatchewan, where considerable damage occurred in 1951. Populations of the red-backed cutworm also were at a low ebb. Slight crop thinning was observed in a few fields near Floral, Grenfell, and Kennedy. A survey in north-central Saskatchewan revealed larvae but no evident damage in a few fields between Radison and Saskatoon, and near Kinistino. Light infestations caused considerable damage in gardens in the Saskatoon area. Light infestations of the bertha armyworm in three flax fields near Nipawin in northeastern Saskatchewan were the first recorded since 1949. The wheat head armyworm, although present in small numbers in many areas, caused negligible damage. *Euxoa detersa* (Wlk.) was scarce in the Floral area, where it had caused noticeable damage in 1951. *Chrysoptera moneta* (F.) caused some damage to delphinium in Saskatoon.

In Manitoba, the red-backed cutworm, along with smaller numbers of the striped cutworm, occurred in the greatest outbreak in at least 30 years, causing extensive damage to field crops, sugar beets, and gardens in all of southern Manitoba except the southwestern area. Severe infestations were reported on gladioli at Arden, and on apple seedlings at Morden. The pale western cutworm caused some damage in three fields of wheat north of Brandon, this being the first record of damage by this species in the Province. The army cutworm was scarce, and the bertha armyworm and the armyworm were not reported.

In Ontario, mixed populations of cutworms, the variegated cutworm predominating, attacked sugar beets in the Chatham-Wallaceburg area, causing damage ranging from a trace to complete destruction in a few fields. Some damage occurred also in tobacco, and in vegetables, including the fruit of tomato. In the Bradford area, severe cutworm damage occurred on all mucksoil crops, particularly lettuce, early in the season; the armyworm was reported in several districts but no damage was observed. Cutworm populations were sharply reduced in comparison with those of 1951 in Hastings County, and no armyworm outbreaks were reported. In the Ottawa area conditions were about average but reports of injury to vegetables in backyard gardens were numerous. In Quebec, species of *Agrotis* and *Euxoa* were reported to have been unusually destructive to seedlings and transplants, even sprouting potatoes being damaged. In the Fredericton area of New Brunswick, large cutworm populations caused considerable damage to potatoes, corn, cucumbers, and other vegetables, and the black army cutworm occurred in even greater numbers on late corn than on early varieties. Two reports were received of the armyworm attacking grain in St. John County, and at Black's Harbour some 45 acres of oats were destroyed. After two years of unusually large numbers of cutworms, particularly *Euxoa* and *Feltia* spp., in Nova Scotia, populations declined to nearly normal. The fall armyworm caused moderate damage to untreated corn, the black cutworm injured onions in Kings County, and moderate local infestations of the armyworm occurred at Milford, Hants County, and in Yarmouth County. In Prince Edward Island, no reports of damage to grain by the red-backed cutworm were received, and little cutworm damage was noted in gardens. Damage in Newfoundland was above average in fields and gardens and persisted until mid-July.

**EUROPEAN EARWIG.**—Populations were reduced in the lower mainland and Vancouver Island areas of British Columbia, but were reported to be increasing in the Okanagan and Kootenay valleys, where the insect was a nuisance to fruit growers. Reports of injury to peaches, cabbage, and corn were received from Kelowna, Nelson, and Creston. It continued to spread to new localities in Ontario, including Durham and Walkerton, the latter record being the first for Bruce County. In St. John's, Nfld., too, continued increase and spread were reported.

**EUROPEAN MANTIS.**—Populations of this beneficial insect predator reached new high levels in eastern Ontario, and specimens were taken for the first time in London and in Kent County in southwestern Ontario.

**GRASSHOPPERS.**—Moderate numbers of grasshoppers, mainly the red-legged grasshopper, were present in the lower Fraser Valley in British Columbia but populations here and on Vancouver Island were greatly reduced from those of 1951. They continued to be rather



troublesome in the Okanagan and Kootenay valleys, mainly in stone-fruit orchards. In the interior of the Province, from Prince George southeast to Roosville, a further increase in numbers made control measures necessary in many districts. *Camnula pellucida* (Scudd.) was the most numerous species above the 2,000 ft. level, and *Melanoplus m. mexicanus* (Sauss.) below that altitude. *M. femur-rubrum* (Deg.) predominated in the Okanagan and Thompson valleys, *M. borealis* (Fieb.) in the northern Cariboo, and *M. bivittatus* (Say) in the Kersley-Quesnel area, where it attained record numbers. Major control measures were necessary in the Nicola zone and lesser efforts in many other areas, including the Peace River district. The fungous disease *Empusa grylli* Fres. effected almost complete control in the Darfield district and was very effective in the Cariboo.

There were fewer grasshoppers in southern Alberta than in any other year of the regular grasshopper survey. Populations attained moderate numbers in only a few localized areas, and practically no damage occurred. In the infested areas, *C. pellucida* was present in greater numbers than in the preceding few years, during which it had been very scarce. *M. bivittatus* was second in importance. The decrease in numbers was attributed to unseasonable weather in 1951. In northern Alberta, grasshoppers were sufficiently numerous in the Peace River district to require control measures. The fall egg survey indicated for 1953 the lowest infestation in 20 years. The only infestations forecast were for small areas about Foremost and near Drumheller, and these were expected to be light.

In Saskatchewan, the usual pest species of grasshoppers, *M. m. mexicanus*, *C. pellucida*, and *M. bivittatus*, continued at a very low ebb and required no control measures anywhere, even on the Regina Plains, where a light infestation had been forecast. Favourable spring weather permitted *C. pellucida* to develop earlier than other species and to deposit a full quota of eggs in the fall, but adults were so few that the species was not expected to be of economic importance in 1953. *M. m. mexicanus* and *M. bivittatus* continued in the retarded status that had been associated with declining numbers, but the latter species may have laid enough eggs to make small, local gains. Small, unpredicted outbreaks of *Aeropedellus clavatus* (Thos.) and *M. confusus* Scudd. developed in a community pasture near Vera, and in a grain field in the Pike Lake district. Fall surveys revealed only a few, scattered areas of oviposition in southwestern Saskatchewan, so small and light as to preclude the forecast of any areas of economic infestation for 1953.

In Manitoba infestation was spotty and confined to the Red River Valley. Hot, dry weather in April resulted in early hatching and also in the desiccation of large numbers of the eggs of *M. bivittatus*. Only minor control measures were required. Fall surveys indicated the lowest population ebb since 1945. Infestations forecast for 1953 were limited to the Red River Valley, and indications were that they would be considerably reduced in intensity and area affected as compared with those of 1952. *M. bivittatus* and *C. pellucida* were equally abundant and *M. m. mexicanus* occurred in sub-economic numbers.

No grasshopper outbreaks were reported in Eastern Canada although some moderate, local infestations developed in the St. Maurice Valley and Portneuf County, Que., and in eastern Ontario, where a marked increase in numbers was noted, *M. femur-rubrum* being the most abundant species. In the latter area several species occur annually in appreciable numbers on semi-waste land.

**JAPANESE BEETLE.**—Trapping of this species was confined to several points in southern Ontario, with over 2,900 traps in operation for two months. The numbers of beetles captured were as follows: Windsor, 41; Fort Erie, 27; Port Burwell, 23; Hamilton, 20; Niagara Falls, 2. The total of 113 was 62 less than the total captured at these points in 1951.

**JUNE BEETLES.**—Infestations in strawberry plantings in southwestern British Columbia were reported to be decreasing as a result of improved methods of control. Increased numbers in light soil areas about Kamloops caused minor damage to vegetables. In Alberta white grubs were reported to be increasing from year to year, and, during 1952, severely damaged potatoes, strawberry plants, and lawns at Medicine Hat. No damage was reported in Saskatchewan but

in Manitoba increased injury occurred on golf fairways at Ninette and Killarney, and in strawberry plantings at Lyleton and La Riviere. *Phyllophaga* spp., mainly in the third-year stage, caused little direct damage in eastern and central Ontario, although local injury to strawberries was reported, and in the Guelph area moderate to severe damage was caused to barley and oats. Heavy weed growth and erosion were evident throughout eastern Ontario where sod had been destroyed by white grubs in 1951. A very large beetle flight is expected in this area in 1953. Large beetle flights occurred during 1952 in the Niagara Peninsula, and along the northwest shore of Lake Ontario, but a decline in the population of this brood was evident. Only minor damage was reported throughout the rest of Eastern Canada, including slight injury to strawberries at Greenwich Ridge and to potatoes in the Annapolis Valley, N.S., and minor damage in central Newfoundland.

**NEMATODES.**—The sugar-beet nematode, *Heterodera schachtii* Schmidt, 1871, did not spread appreciably in Ontario in 1952 but in the Sarnia area populations remained at a high level. New host plant records for this species at Sarnia included Swiss chard and horse radish. The oat nematode, *Heterodera avenae* Lind, Rostrup, and Ravn, 1913, apparently continued to spread and cause crop losses of importance in central Ontario. The status of the wheat nematode, *Heterodera punctata* Thorne, 1928, which had been first recorded from wheat in Saskatchewan and Alberta, was not known. The pea nematode, *Heterodera göttingiana* Lieb., 1892, was recorded from British Columbia. The potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, was comparatively scarce in Prince Edward Island. *Ditylenchus dipsaci* (Kuhn, 1857) Filipjev, 1936, was recorded from a variety of plants in British Columbia, Alberta, Ontario, and New Brunswick, but more than one species may be involved. *Ditylenchus graminophilus* (Goodey, 1933) Filipjev, 1936, was reported to be widely distributed in Quebec and was recorded from Manitoba. The meadow or root-lesion nematodes, *Pratylenchus pratensis* (de Man, 1880) Filipjev, 1936, caused damage to red clover at Ottawa. Other forms of this complex were collected from tobacco and from peach orchard soil at Harrow, Ont. A grass nematode, *Anguina agrostis* (Steinbuch, 1799) Filipjev, 1936, was recorded from Saskatchewan and Nova Scotia. Root-knot nematodes, *Meloidogyne* spp., are common in Canada, *M. hapla* Chitwood, 1949, probably being the commonest species. *Aphelenchoides ritzema-bosi* (Schwartz, 1911) Steiner, 1932, occurred frequently in Canadian greenhouses, and attacked chrysanthemums in a garden at Sarnia. *A. fragariae* (Ritzema Bos, 1891) Christie, 1932, was recorded from British Columbia and Ontario. *A. parietinus* (Bastian, 1865) Steiner, 1932, is probably widespread, as is also *Aphelenchus avenae* Bastian, 1865.

**PAINTED-LADY.**—Larvae of this butterfly were reported to be numerous on Canada thistle in the Crescent district in British Columbia. Unusually large flights of adults invaded the Prairie Provinces from the south, and although a comparable larval population failed to develop in all areas, considerable feeding occurred on Canada thistle, and sunflower was slightly damaged at Saskatoon, Sask., and in southern Manitoba. The insect appeared also in unusual numbers in parts of Eastern Canada, a severe infestation being reported for the first time from the La Pocatiere, Que., area, where sunflowers were extensively damaged and a second generation appeared in August.

**RED TURNIP BEETLE.**—No economic damage was reported during the season but the insect was recorded at Mamette Lake, B.C., and large numbers of adults fed on *Sisymbrium altissimum* L. in the Rolling Hills, Alta., district. It was common throughout northwestern Saskatchewan, notably in the Primate-Kingsland area, and in Saskatchewan larvae fed on cruciferous weeds at North Battleford and adults were found in a pasture at Davidson.

**TARNISHED PLANT BUG.**—This insect was considerably more numerous than usual throughout Eastern Canada, and in New Brunswick was rated the most numerous pest of the season. Sugar beets, potatoes, cucumbers, celery, lettuce, peaches, beans, clover, alfalfa, and many flowering plants, notably dahlia, gladiolus, chrysanthemum, aster, and zinnia, were generally damaged from Ontario eastward to Prince Edward Island.

**WIREWORMS.**—On Vancouver Island, B.C., insecticides were used generally to reduce losses caused by the Puget Sound wireworm. On the mainland, *Agriotes obscurus* (L.), one of the most injurious European wireworms, destroyed a 14-acre field of corn and damaged fall rye near Agassiz in the lower Fraser Valley. This was the first record of this species on the mainland of British Columbia.

In northern Alberta, moderate wireworm damage to potatoes and other susceptible crops was reported from the Peace River district. A survey in various parts of southern Alberta revealed damage counts ranging from a trace to 75 per cent. The survey indicated also that almost all districts are susceptible to infestation, and that a very great wireworm potential exists. Damaged crops included winter wheat, barley, oats, flax, and some garden crops. Fields required reseeded near Lethbridge, Readymade, Champion, Granum, Claresholm, Bow Island, Warner, and Drumheller. The most numerous species were *Ctenicera aeripennis destructor* (Brown) and *Hypolithus nocturnus* Esch.

In Saskatchewan, damage by wireworms to grain crops was slightly more severe and somewhat earlier than in 1951. *C. aeripennis destructor* was again responsible for widespread thinning of cereal crops on loam, silty clay, and clay loam soils throughout central and western Saskatchewan. The slight increase in damage was apparently attributable to an increase in numbers, particularly of *H. nocturnus*, associated with high moisture conditions in 1950 and 1951. Surveys indicated traces to general light thinning of grain crops in the east-central, west-central, and extreme southern and northern parts of the agricultural area of the Province. Moderate thinning occurred mainly in the central portion of the Province. However, moderate to severe thinning of wheat on summer-fallow was general in the Meadow Lake, Melfort, Saskatoon, Mildred, Stewart Valley-Saskatchewan Landing-Kyle, Kerrobert, and Hanley-Hawarden-Craik districts. Several fields of barley on stubble in loam soils were severely thinned in the Meadow Lake area. As usual, damage to garden crops, particularly potatoes, was severe throughout the prairie and adjacent parkland areas. Relatively little damage occurred in Manitoba, but near Dugald *H. nocturnus*, *Ctenicera* spp., and *Limonius* spp. together caused considerable damage to 25 acres of wheat and an adjacent field of corn.

Wireworms of various species were reported throughout Eastern Canada, but, except possibly in Nova Scotia, no major economic damage was known to have occurred. In southwestern Ontario minor losses occurred, mainly in crops planted early. Damage to potatoes was considerably less than in 1951. In the Dresden and Highgate areas, *Aeolus mellillus* (Say) was scarcer than in 1951, when it formed four to six per cent of the wireworm population. Some minor damage in crops planted in sod was reported from Quebec. In New Brunswick local damage was caused to potatoes at Lincoln. In Nova Scotia, wireworms, more numerous than in 1951, were very injurious to potatoes and other crops in Yarmouth, Digby, and Halifax counties. *Agriotes mancus* (Say), the chief species, was associated with *A. lineatus* (L.), *A. sputator* (L.), and *A. obscurus* (L.). *Dalopius* sp. was numerous in dyked land near Port Williams, and damaged turnips at Starr's Point. *Ctenicera* sp. was moderately abundant on dyked land near Grand Pré. In Newfoundland, *A. lineatus* was abundant on the Avalon Peninsula, causing considerable damage to potatoes.

#### FIELD CROP INSECTS

**APHIDS.**—The English grain aphid was present in many oat fields in southwestern British Columbia but was much less abundant than in 1950 and 1951 and caused little injury. The only reported aphid infestations on grain in Alberta occurred in the Peace River area at harvest time. In Saskatchewan the English grain aphid was very abundant on cereals over a large area during the pre-ripening period. Wheat and oats, in particular, were severely infested throughout the agricultural area of the Province as far north as Prince Albert and Nipawin, but no serious damage was reported. Fall-seeded rye was very lightly infested in the Nipawin-Carrot River area. For the first time in four years the greenbug was not reported. *Brachycolus tritici* Gill. caused more injury than usual on *Agropyron* and *Agropyron*-wheat hybrids at Saskatoon. In Manitoba, unspecified grain aphids destroyed a field of late barley at Morden, and damaged late wheat at



Russell and Cowan. The pea aphid occurred on alfalfa at Portage la Prairie, Man., and in small numbers on red clover and alfalfa at Ottawa, Ont. The clover aphid, *Anuraphis bakeri* (Cowen), apparently not reported in British Columbia since 1929, was found at various points throughout the lower Fraser Valley. The corn leaf aphid was reported from Ontario, Quebec, and Nova Scotia, but was of minor economic importance. In some irrigated areas of southern Alberta the sugar-beet root aphid damaged sugar beets, and in the Chatham area of Ontario threatening infestations developed during the early-season dry period, but disappeared later after normal rainfall. The apple grain aphid occurred commonly on wild rice late in September in eastern Ontario.

**ARCTIIDS.**—*Apantesis williamsi* Dodge, which destroyed several fields of spring wheat and fall rye at Turin, Alta., in 1951, was not noted in 1952, and for the first time in several years *Apantesis blakei* Grt. was not found in the Leader-Empress area of southwestern Saskatchewan. *Diacrisia* spp. were observed in small numbers on alfalfa in northeastern Saskatchewan but no damage was reported. *Colias eurytheme* Bdv. occurred in larger numbers than usual on alfalfa at Scandia and Rolling Hills, Alta., but caused little damage. This species and *C. philodice philodice* Latr. were reported to be scarce in Manitoba.

**BARLEY JOINTWORM.**—Barley in north-shore areas of Prince Edward Island was severely damaged, infestation ranging from 90 to 100 per cent of the plants. Infestations were lighter in southern areas, and none were observed west of Summerside.

**BURROWER BUGS.**—There was no recurrence of *Sehirus cinctus* (P. de B.) in clover crops in the Prince George and Salmon River district of British Columbia, although a few were observed on decaying vegetation. When abundant the insects become mixed with the clover seed, causing it to be sticky and thereby greatly increasing the cost of cleaning.

**CLOVER SEED MIDGE.**—This midge was abundant on first-cut red clover in Carleton and Renfrew counties, Ont., but damage was greatly reduced from that of 1951.

**CLOVER WEEVILS.**—The sweetclover weevil was again abundant in the prairie area, notably in the irrigation districts of Alberta, in northeastern Saskatchewan, and in southern Manitoba. In general, clover outgrew early injury but in the Morden and Portage la Prairie areas of Manitoba considerable damage was caused to first-year crops that had been seeded alongside old clover fields. In southwestern Ontario, where precipitation was low, adults severely damaged seedling clover, and larvae caused extensive root damage to year-old plants. These crops were severely injured also at Renfrew, Ont. *Sitona lineata* (L.) was injurious to clover in pastures at Hillbank, B.C., and was of minor importance on peas. *Sitona tibialis* (Hbst.), although prevalent in northeastern Saskatchewan, caused little damage. *Tychius picirostris* (F.) was found on alsike clover as far north as the Salmon River Valley, B.C. In the Ottawa, Ont., area, *Sitona hispidula* (F.) was numerous on red clover, and *Tychius stephensi* Schönh. occurred on red clover but damage was not serious. *Hypera nigrirostris* (F.) occurred on red, alsike, and ladino clovers in this area, causing some damage to first-cut red clover, and in Newfoundland this species was recorded for the first time on red clover, the yield being significantly reduced.

**CORN BORERS.**—The European corn borer was recorded in only one garden in Saskatchewan. An infestation on corn at Morden, Man., was reported to be the lightest since the introduction of the pest into the Province in 1949, and no commercial damage occurred. In southwestern Ontario, with minor exceptions, infestation was very light, second-generation larvae being more numerous than those of the first generation. Stalk infestation was about 50 per cent in the Bradford, Ont., area but ear infestation was low. At Ottawa and elsewhere in eastern Ontario damage to sweet and fodder corns was the greatest in several years. Average infestation for the Province of Quebec was reported to be nine per cent, but at St. Jean, where populations showed an increase for the second successive year, damage was much greater, a local canning factory reporting 25 per cent cob infestation. In New Brunswick damage was general and was reported to be considerable in the Grand Lake district and the St. John River Valley. Contrary to normal, cobs were more severely infested than stalks at Fredericton, probably because of drought condi-

tions. Throughout Nova Scotia, too, corn was severely attacked. A western corn borer, *Helotropha reniformis* (Grt.), was recorded from corn at Dauphin, Man., and the stalk borer, *Papaipema nebris* (Guen.), was found in young corn at Winnipeg, Man.

**CORN EARWORM.**—All provinces in Western Canada reported no damage, and occurrence records were received only from Taber and Medicine Hat, Alta., and one locality in southwestern Saskatchewan. Infestation of corn was light in southwestern Ontario but in central areas of the Province the insect was generally more abundant than for several years; all fields of canning corn were infested and in one case one-third of the cobs were attacked. Little damage was reported in Quebec but, excepting Prince Edward Island, infestation was generally severe on late corn throughout the Maritime area.

**FLEA BEETLES.**—Adults of the red-headed flea beetle damaged the leaves and florets of red clover in the Ottawa, Ont., area, and the first recorded occurrence of the cruciferous flea beetle *Psylliodes chrysocephala* (L.) in North America was made at Topsail, Nfld., where it occurred on rape.

**HESSIAN FLY.**—Light damage by the species occurred on winter wheat in the Armstrong area of British Columbia, and no damage was reported in the Prairie Provinces. Only trace infestation was recorded in southwestern Ontario, where a severe outbreak had occurred in 1951; heavy parasitism and unfavourable weather were believed to have reduced the population.

**LEGUME-POLLINATING INSECTS.**—Weather conditions in Saskatchewan were more favourable for pollinator activity than during the years 1949 to 1951. *Bombus terricola* Kby. and *B. ternarius* Say were the chief bumble-bee pollinators of alfalfa, although several other species of *Bombus* were observed in alfalfa fields. *Megachile* spp. appeared to be less abundant than in 1951. In Manitoba the principal pollinators of this genus were practically eliminated by land clearing in south-eastern areas; elsewhere populations fluctuated according to agricultural practices, large numbers occurring in some isolated areas. *Bombus* spp. were somewhat less abundant than in 1951 in alfalfa and sweet clover in Manitoba, but in eastern Ontario populations on red clover were much larger than in 1951 and seed set was excellent.

**LEAFHOPPERS.**—Several species of leafhoppers, including the clover leafhopper and *Agaliopsis novella* (Say), were observed in alfalfa fields in northeastern Saskatchewan but no damage was noted. A severe infestation of the six-spotted leafhopper occurred in a field of grain near Prince Albert, Sask. Populations of this species were small on clovers in eastern Ontario, but were larger than in 1951. The potato leafhopper caused severe yellowing of alfalfa in this area and occurred also on red clover.

**MITES.**—The so-called blue oat mite, *Penthaleus major* (Dugès), caused appreciable damage to orchard grass and red clover in two fields at Courtenay, B.C., and in the Okanagan and Kootenay valleys the clover mite was a pest of economic proportions in many fruit orchards. The two-spotted mite was numerous on red clover in eastern Ontario in September but caused little damage.

**PLANT BUGS.**—Population counts made in alfalfa fields in the Scandia, Rolling Hills, Irvine, and Wild Horse districts of Alberta revealed no infestations of *Lygus* spp. extensive enough to be of economic importance. In northern Saskatchewan, however, they were the most common of the injurious insects in alfalfa fields. In Manitoba the tarnished and alfalfa plant bugs occurred in about equal numbers in the southeastern corner of the Province, but at Wanless the former species predominated. In eastern Ontario the tarnished plant bug was much more abundant than in 1951, and was present in all clover and alfalfa fields examined. *Adelphocoris rapids* (Say) was of little importance on alfalfa in Saskatchewan and Manitoba. *A. lineolatus* (Goeze) was believed to have caused considerable bud blasting at Hudson Bay, Sask., the first record of economic damage by the species in the Province. Elsewhere in Saskatchewan and in Manitoba it was scarce. In Ontario it was very numerous on alfalfa early in the season in Renfrew County. *A. superbus* (Uhl.) was present in all alfalfa seed fields examined in Alberta, populations varying according to cultural practices. In northeastern Saskatchewan *Plagiognathus obscurus*, probably

var. *fraternus* Uhl., occurred on alfalfa in varying numbers, ranging up to 25 per net sweep in the White Fox district, and *Chlamydatus* sp. was observed in small numbers, neither species causing any apparent damage. *Capus simulans* (Stål) and *Irbesia arcuata* Van D. were taken for the first time in the Lethbridge area of Alberta, where they damaged a plot of *Agropyron intermedium*.

**SAY STINK BUG.**—Populations in southern Alberta were at the lowest level since the appearance of the bug in 1934, and it was not reported on wheat in Saskatchewan.

**SOD WEBWORMS.**—In southwestern British Columbia, several species of the genus *Crambus* caused economic damage in several fields of sod and in at least one corn field.

**SPITTLEBUGS.**—Populations were unusually large on red clover, alfalfa, and other crops in southwestern Ontario, the meadow spittlebug predominating. Spittlebugs were common in eastern Ontario and Quebec but damage was negligible.

**SUNFLOWER INSECTS.**—In Manitoba, no specimens of the sunflower moth were observed. *Phalonia hospes* Wlsh. was less abundant than in 1951, apparently because of parasitism, which amounted to some 65 per cent. Damage amounted to two per cent as compared with 6.5 per cent in 1951. The sunflower beetle occurred in outbreak numbers, severely damaging commercial crops in the Altona area for the first time; some crops were ploughed under. The percentage of plants infested by the sunflower maggot dropped from a high of 96.4 in 1951 to 69.7, and, in addition, there were fewer larvae per plant. Oviposition by the painted-lady was heavy but damaging larval populations failed to develop. Excessive cultivation had almost eliminated *Melissodes* spp., effective native pollinators of sunflower, by 1952. No specimens of *Eucosma* spp. were observed. *Oedicarena diffusa* Snow. occurred generally in greater numbers than in recent years but its economic importance is not known.

**TOBACCO INSECTS.**—A limited infestation of the tobacco budworm occurred on burley tobacco near Chatham, Ont., in July, an unusually early appearance. Infestations of the green peach aphid, although general in southwestern Ontario, were the lightest in several years and caused little damage. Injury by the tomato hornworm was generally light to moderate. The first recorded infestation of the tobacco hornworm in Canada caused extensive late-season damage to flue-cured tobacco in the Leamington, Ont., area. Previously, only occasional specimens had been reported.

**WHEAT STEM MAGGOT.**—More abundant than for several years in Saskatchewan and Manitoba, this insect caused marginal damage ranging up to 10 per cent "white heads" in several fields in the Lake Alma, Weyburn, Radville, Ceylon, Estevan, and Regina districts of southeastern Saskatchewan; infestations were reported also at Davidson, Simpson, Delisle, Hanley, Langham, and Saskatoon in central Saskatchewan. It was the subject of many inquiries in Manitoba, and at Melita counts indicated infestations of 2 to 4 per cent.

**WHEAT STEM SAWFLY.**—In Alberta, wheat varieties susceptible to the sawfly were very severely cut (40 to 100 per cent) in the Carmangay-Barons-Nobleford areas, and severely cut (25 to 39 per cent) in the areas of Vulcan-Lomond-Champion-Enchant-Monarch, Lethbridge-Stirling, Legend, Nemiscam, and Warner. Moderate cutting (6 to 24 per cent) occurred in the area bounded by a line through Hilda, Cereal, Consort, Castor, Wainwright, and the Saskatchewan-Alberta border, as well as in the area within a line from the International Border through Pakowski, Medicine Hat, Bow Island, Retlaw, Alderson, Milo, Stavelly, Fort Macleod, Magrath, and Coutts. In Saskatchewan, there was a reduction in the sawfly infestation as compared with 1951, and also a general lessening of the losses because of the over-all heavy crop stand, which permitted a high recovery of cut stems at harvest. The infested area remained substantially as in 1951 but there was a considerable reduction in the extent of the very severe (40 to 100 per cent) category in the area south from Moose Jaw and Regina, and in the extent of the moderate (6 to 24 per cent) category in parts of central, west-central, and southwestern Saskat-



chewan. In Manitoba infestation continued to be very light. The European wheat stem sawfly occurred on winter wheat in southwestern Ontario in the most severe infestation on record; up to 24 per cent cutting of stems was observed near Stratford.

#### VEGETABLE INSECTS

**APHIDS.**—The cabbage aphid was prevalent for the third successive year on Vancouver Island, B.C. Infestation was moderate on cruciferous vegetables in southwestern and central Ontario, but 20 acres of late cauliflower were severely infested in Essex County, and a few fields of turnips were extensively damaged. Little damage occurred in eastern Ontario and Newfoundland. Large populations were reported near Montreal, Que. Aphids on potato, notably *Macrosiphum solanifolii* (Ashm.), were scarce in Manitoba, unreported in Ontario, and more abundant than usual in many areas of Quebec. In the Gulf of St. Lawrence area, populations were phenomenally small in New Brunswick, very small in Newfoundland, and small on late-planted crops in Prince Edward Island although earlier crops were infested considerably. *Myzus persicae* (Sulz.) caused almost complete loss of radish throughout the season in a market garden at Regina, Sask. The pea aphid was abundant on all leguminous forage crops in southwestern Ontario; little damage occurred on canning peas in Kent County but control measures were necessary in Essex County. In Nova Scotia, too, this crop was infested considerably. Severe infestations of the melon aphid occurred on all vine crops in extreme southwestern Ontario, muskmelon and squash being totally destroyed in some areas. Turnips at Craven, Sask., were severely damaged by the corn root aphid.

**ASPARAGUS BEETLES.**—The most severe infestation of *Crioceris asparagi* (L.) in 16 years combined with adverse growing conditions to reduce the asparagus yield to two-thirds of normal in many areas of Essex and Kent counties, Ont. By comparison, *C. duodecimpunctata* (L.) occurred in very small numbers. Both species were present at Bradford, Ont., but damage was light. *C. asparagi* was reported as being moderately injurious in the Montreal and Quebec City areas of Quebec, and at Fredericton, N.B. Neither species was observed at Kentville or Truro, N.S.

**CABBAGEWORMS.**—The imported cabbageworm was somewhat more abundant than usual in southwestern British Columbia, and prevalent in southern areas of the Prairie Provinces where not controlled. Damage was more severe than in 1951 at Saskatoon, Sask., and in northwestern areas of the Province 60 to 70 per cent of cole crops suffered moderate defoliation. Early infestation was somewhat less than in 1951 in southwestern Ontario, but elsewhere in the Province was greater than usual, resulting in an increase in early crop damage and a rapid build-up in populations generally. In study plots at Ottawa this species comprised 83 per cent of the total cabbageworm population from May 23 to July 24. Severe over-all damage was reported also from Quebec. In the Gulf of St. Lawrence area, moderate numbers were reported from New Brunswick, normal populations in Nova Scotia, and above average numbers in Prince Edward Island and Newfoundland, turnips being severely damaged in the former province and late cruciferous crops in both. Adults of *Pieris occidentalis* Reak. occurred commonly with those of *P. rapae* (L.) during spring flights in Manitoba. The cabbage looper was scarce in Manitoba but populations were larger than usual in southwestern Ontario, where they exceeded those of *P. rapae* toward the end of the season, and in the Harrow area caused considerable defoliation of canning tomatoes. At Ottawa the looper composed one per cent of the cabbageworm population between May 23 and July 24. No extensive damage was reported from the Maritime Provinces. The diamondback moth was present in moderate numbers in the lower Fraser Valley, B.C., where it had not been observed for 15 years. It did not occur in economic numbers in the Prairie Provinces, and at Ottawa, Ont., it comprised 16 per cent of the cabbageworm population between May 23 and July 24. Some late-season damage was reported from Newfoundland, where *Evergestis pallidata* (Hufn.) also occurred in sufficient numbers to cause some damage to turnips. The salt-marsh caterpillar, not previously observed on late cabbage in Newfoundland, caused negligible damage to this crop.

**CARROT RUST FLY.**—In British Columbia injury was comparatively light in the lower Fraser Valley, and somewhat less severe than usual in the Okanagan Valley north from Kelowna and in the Nelson area. Late infestations caused considerable damage on Vancouver Island and severe damage occurred at Armstrong. In Ontario little injury occurred on early carrots but later crops were severely attacked, notably in the Bradford area, where damage was the most severe on record, records having been kept since 1947. At Burlington and London celery, too, was injured. Crops in eastern Ontario were less severely attacked. Moderate to severe injury was reported in Quebec. In the Gulf of St. Lawrence area, reduced populations and damage were reported in Nova Scotia and Prince Edward Island. Carrots and parsnips were extensively attacked in York and Sunbury counties in New Brunswick, and the insect continued to be a serious pest in Newfoundland.

**COLORADO POTATO BEETLE.**—Adults were abundant on untreated potatoes early in August at Cranbrook, B. C. Parasitism by *Doryphorophaga doryphorae* (Riley) averaged over 50 per cent in early August in the East and West Kootenays. In Saskatchewan the insect was virtually absent for the second successive year, and at Brandon, Man., overwintering adults were so scarce that little control was practised, resulting in a considerable number of first-generation adults in August. Populations in Ontario have been increasing, probably partly a result of inadequate control, and in 1952 were very injurious in many areas. The numbers observed on wild nightshade indicate this plant to be an important carrier host. Conditions in Quebec were comparable to those in Ontario. The insect was normally abundant in Nova Scotia but was not found on untreated potatoes at Chebogue Point, Yarmouth County. Populations were larger than in 1951 in Prince Edward Island.

**BETTER ON CUCUMBER.**—All species were much more numerous than in 1950 and 1951 in southwestern Ontario, and damage was severe, particularly in kitchen gardens. In the Ottawa area very little damage has occurred in recent years, and the beetles were almost absent in 1952. Some injury was reported in Prince Edward County and at Bradford, Ont. Damage by the striped cucumber beetle ranged from very light to moderate in Quebec, was reported as 20 to 40 per cent in York and Sunbury counties, N.B., and was more numerous than in 1951 in Kings County, N.S. The spotted cucumber beetle predominated at Chatham, Ont., during the fall. *Diabrotica longicornis* (Say), not observed at Chatham in 1950 and 1951, occurred in approximately equal numbers with other beetles on cucumber in late-season infestations.

**FLEA BEETLES.**—The potato flea beetle was not reported in Saskatchewan, and in Manitoba was scarce in the Brandon area, abundant in the Swan River Valley, and moderate at Douchin. It was generally reported as being present throughout the season and causing light to moderate injury in all of Eastern Canada. Early tomatoes and potatoes were the main plants attacked but egg plant, peppers, and cucumbers also were affected. Populations showed some increase in Nova Scotia and Prince Edward Island. The western potato flea beetle was very abundant in the Soda Creek, B.C., area, causing severe defoliation and some tuber damage. Control measures appeared to have reduced populations of the tuber flea beetle in southwestern British Columbia, but in the Okanagan, Thompson, and Nicola valleys potatoes were severely damaged. *Phyllotreta* spp. caused considerable damage to sugar beets. *P. aerea* Allard was common at Chatham, Ont. *P. striolata* (F.) was present in Manitoba, and numerous on turnips in New Brunswick and Newfoundland.

**LEAFHOPPERS.**—The potato leafhopper was generally reported from Manitoba eastward but no serious damage was noted. Rather large populations were present in south-central and eastern Ontario, and in Prince Edward Island. A species of *Empoasca* encountered annually in British Columbia occurred in considerable numbers on carrots at Grand Forks and on potatoes at Soda Creek. The six spotted leafhopper occurred in normal numbers on potatoes and caused some yellows in asters and carrots in Manitoba. Heavy infestations of *Macrostelus* sp. caused little apparent damage to lettuce at Erieau, Ont.

**MAGGOTS IN ONIONS.**—The onion maggot was present in large numbers in British Columbia and Alberta, over 50 per cent infestation occurring in commercial plantings at Medicine Hat. In Saskatchewan a survey revealed the pest to be present in practically all

gardens, damage ranging from 40 to 100 per cent. In Manitoba the second generation caused the following percentages of damage in the areas indicated: Winnipeg, 10 to 16; Portage la Prairie, 15; Brandon 45. Injury was well above average in southwestern and central Ontario, reaching 25 per cent in some Holland Marsh crops. Fifteen to 20 per cent damage occurred in muck land near Montreal and Ste. Clothilde, Que., and up to 30 per cent in sandy loam. Maggot attacks were severe at Sussex, N.B., moderate at Charlottetown, P.E.I., and of minor economic importance in Nova Scotia. Large numbers of larvae of *Paragopsis strigatus* (Fall.) were associated with the onion maggot in British Columbia, probably as a secondary pest.

**MEXICAN BEAN BEETLE.**—Moderate infestations occurred on red kidney beans in the Thedford, Ont., area; local infestations were reported from Aylmer, St. Hilaire, St. Antoine Abbé, and St. Jean Chrysostome, Que.; and an attack was recorded at Milltown, N.B.

**MITES.**—Considerable mite damage, probably caused by the two-spotted mite, occurred on potatoes near Kamloops, B.C., and a severe infestation occurred on strawberries in the Magna Bay, B.C., district. For the first time on record in Canada, russetting and defoliation of tomato plants was caused by the tomato russet mite, *Vasates destructor* (Keif.), in southwestern Ontario; all infestations were associated with plants imported from the State of Georgia, U.S.A.

**ONION THRIPS.**—Large populations of thrips caused commercial damage to onions where control measures were not applied in southwestern and south-central Ontario.

**PEA MOTH.**—Numbers were small in the Fraser Valley, B.C., where most peas are harvested green. General abundance was reported in Kings County, N.S., and in home gardens in Prince Edward Island.

**POTATO STEM BORER.**—This borer caused light damage to corn and potatoes in Kings and Colchester counties, N.S., and was found in a few gardens in Newfoundland.

**ROOT MAGGOTS ON CRUCIFERS.**—Root maggots, chiefly the cabbage maggot, were normally abundant where not controlled in southwestern British Columbia, but inquiries were few in the Kamloops, B.C., area. In Alberta, cabbages were only slightly affected, and turnips in the Lethbridge irrigation area were not severely attacked. The cabbage maggot continued to be the major pest of crucifers in southwestern Ontario, and in the Bradford, Ont., area caused up to 75 per cent damage to cabbage and cauliflower, and complete loss in some turnip fields, where not controlled. In the Ottawa, Ont., area, more eggs were laid per cabbage plant than in any other year since records were begun in 1946, except 1951, when almost twice as many were laid as in 1952. Damage generally was less severe than in 1951 and remarkably light on swede turnips. No reduction in damage was reported in Quebec, extensive losses being reported in all agricultural areas. Root maggot populations were unusually large in New Brunswick and Nova Scotia in the early part of the season, but damage to late crops, notably turnips, was much lighter than usual throughout most of the Maritime area. The turnip maggot, *Hylemya floralis* (Fall.) [= *H. crucifera* Huck.], was very scarce until late in the season at Kamloops, B.C. Surveys in Saskatchewan revealed moderate infestations on cruciferous vegetables in dry-land gardens throughout southern areas. Northward from Saskatoon infestation increased as moisture conditions improved. At Loon Lake in the west and Duck Lake in central Saskatchewan all cole crops were moderately infested, and at outpost settlements in north-central and north-eastern areas they were severely infested, 10 to 30 per cent of nearly mature plants being killed. Market gardens in nearly all urban centres suffered 80 to 100 per cent infestation of cole crops. Infestation was general also in Manitoba, with large populations present about Brandon. Numbers in New Brunswick were limited by drought conditions in July, and reduced populations were reported from Newfoundland. *Hylemya planipalpis* (Stein.) was common on radish throughout Saskatchewan, and infested up to 50 per cent of radish and turnips in some gardens at Brandon, Man.

**SEED-CORN MAGGOT.**—Scarcely any damage occurred on beans in southwestern Ontario, where infestation was the lightest ever recorded. In Quebec and New Brunswick, too, infestation was less than usual, although early-season injury was appreciable in some areas. Beans were



severely injured in many parts of Nova Scotia, and in Prince Edward Island beans and cucumbers grown commercially were severely attacked, necessitating some replanting. In Newfoundland populations were somewhat smaller than in 1950 and 1951.

**SLUGS.**—Damage by slugs was more noticeable than usual in Kamloops and Vernon gardens in both 1951 and 1952. Throughout the Prairie Provinces favourable moisture conditions resulted in an abundance of slugs well through the summer. Populations have been large at Winnipeg, Man., since the floods of 1950. Dry weather hindered development in southern Ontario but in eastern areas and in Quebec normal numbers appeared. In much of the Gulf of St. Lawrence area wet weather promoted large populations and above average damage to vegetables, especially during June.

**SPINACH LEAF MINER.**—An occurrence at Wilkie, Sask., was reported, and at Regina 20 to 25 per cent of the leaves of spinach and beets were infested in a truck garden. Some damage occurred on canning spinach in Manitoba, and in southwestern Ontario greatly reduced numbers caused negligible losses.

**SPRINGTAILS.**—Beans were severely damaged in the Lethbridge, Alta., area, and peas and beans were affected at Regina and Meacham, Sask. Large numbers occurred in potato fields at St. Anne de la Pocatiere, Que., and in the Waterford Valley area of Newfoundland, causing negligible damage.

**SQUASH BUG.**—Widespread, light infestations of this species occurred in Ontario, causing little damage.

**SQUASH VINE BORER.**—As usual, in southwestern Ontario, heaviest infestations of this species occurred in home gardens but commercial plantings of Hubbard squash and Boston marrow also were extensively damaged.

**A STINK BUG.**—Several fields of canning tomatoes were injured by *Euschistus euschistoides* Voll. in Prince Edward County, Ont.

**TOMATO HORNWORM.**—A single larva taken on tomato in a garden at Carnduff, Sask., constituted the first record of this species for the Province. Greatly reduced numbers in Ontario and Quebec caused negligible damage to tobacco and tomato in 1952.

**MISCELLANEOUS.**—Economic infestations of the black swallowtail occurred on carrots in the Springhill and Kentville districts of Nova Scotia. A severe infestation of the garden centipede ruined seedlings and transplants in a garden at Victoria, B.C. An unusual outbreak of the greenhouse leaf tier in a half-acre field of head lettuce rendered 50 to 60 per cent of the heads unmarketable in the Erie marsh area, Ont. A further increase of *Lygus campestris* (L.) was noted on carrot seed crops at Grand Forks, B.C., but populations were still small as compared with those of 1947 and 1948. The spinach carrion beetle severely defoliated sugar beets in Alberta but the plants outgrew the damage. The zebra caterpillar caused considerable damage to sugar beets at St. Hyacinthe, Que.

#### FRUIT INSECTS

**APHIDS.**—In British Columbia, *Aphis pomi* Deg. was not as abundant on apples as in 1951, but control measures were necessary in some areas. In Ontario moderate infestations were general, requiring control in eastern districts. The insect, although common, was a minor pest in Quebec and New Brunswick. In Nova Scotia both *A. pomi* and *Anuraphis roseus* Baker were unusually abundant but damage to the apple crop was comparatively light, predators being very effective in most orchards. *A. roseus* was not reported to be important other than in Nova Scotia. The apple grain aphid was present in moderate numbers early in the spring in this province. The woolly apple aphid was more troublesome than for several years in British Columbia; it increased slightly in numbers in Essex County, Ont., and remained comparatively scarce in Nova Scotia. The black cherry aphid was less troublesome than in previous years in British Columbia and was scarce in Ontario. Extensive populations of the black peach aphid were noted on peach

in Essex County, Ont., during October and early November; most severe infestations occurred on nursery stock and young trees. The green peach aphid was present in limited numbers in western areas of New Brunswick. The currant aphid was a general pest on currants throughout the Prairie Provinces. The mealy plum aphid was a serious problem on plum in coastal areas of British Columbia, and occurred in small numbers on apricot and prune in the Okanagan and Kootenay valleys. Aphids, on strawberry, *Capitophorus* sp. and *Myzus porosus* Sanderson, were very scarce in New Brunswick.

**APPLE AND PEAR PSYLLIDS.**—The pear psylla was less troublesome than usual in the Okanagan and Kootenay valleys, B.C. Damage was generally light in Ontario, excepting in a few orchards in Essex and Norfolk counties. Little change in status was noted in Nova Scotia, but considerable injury occurred on pears in orchards where control measures had not been applied for several years. In this province, too, the apple sucker was present in small numbers in some orchards.

**APPLE AND THORN SKELETONIZER.**—This insect continued to be the most serious pest of unsprayed apple and ornamental hawthorn in the Victoria, B.C., district.

**APPLE (AND BLUEBERRY) MAGGOT.**—Hawthorn was infested by this species at Morden, Altamont, and Mariapolis, Man., but samples collected at various other points in the Province and in Saskatchewan were not infested. A general increase in numbers was indicated in Ontario, and in parts of Quebec, notably the St. Jean district. Populations appeared to have increased slightly in some New Brunswick orchards, and in Nova Scotia commercial orchards infestation was very limited. Large populations of the maggot were generally present on unsprayed apple and hawthorn throughout apple-growing districts of Eastern Canada. This insect was again prevalent in commercial blueberry areas in Charlotte County, N.B., and in other areas, notably along the northeastern shore. Light infestations were reported in the blueberry areas of Prince Edward Island, and in Newfoundland the crop was comparatively free of infestation except in a few localities, notably the Carbonear, Grate's Cove, and Western Bay areas.

**APPLE MEALYBUG.**—Small populations were present in many orchards in the St. John River Valley, N.B., and in some Nova Scotia orchards, but no economic damage was reported.

**APPLE SEED CHALCID.**—Infestation was high on unsprayed crab-apple trees at Morden, Manitoba

**BLUEBERRY CUTWORMS.**—The black army cutworm, which has been decreasing since 1944 in New Brunswick, increased considerably on blueberry in the Pennfield area. Populations of other cutworms showed little change. Five species not previously taken on blueberry were recorded in 1952: these included *Eurois stricta*, Morr., *Graphiphora c-nigrum* (L.), *Lacinipolia lorea* Gn., *L. lustralis* Grt., and *Syngrapha octoscripta* Grt.

**CHERRY FRUIT FLIES.**—*Rhagoletis cingulata* (Loew), which infests both sweet and sour cherries, continued to inflict severe losses on Vancouver Island, some crops being unmarketable. Normal numbers were reported in Prince Edward Island, mainly at Summerside and Montague. *Rhagoletis fausta* (O.S.), which infests only sour cherries, was of minor importance on Vancouver Island, and had not spread in the Okanagan Valley, B.C., where it was apparently limited to a single orchard near Westbank. In Manitoba an infestation occurred on pin cherry at Morden.

**CHERRY FRUITWORM.**—Some increase was indicated on Vancouver Island, B.C., losses being experienced by several growers of sour cherries in the Keating area. On the mainland, infestation was limited to the East Kelowna, B.C., area, where little damage occurred in sprayed orchards; unsprayed crops, however, were severely infested.

***Chlamisus fragariae* Brown.**—This new strawberry pest again caused severe damage in several plantations of the Senator Dunlap variety in the Belleisle, N.B., area; both larvae and adults fed voraciously on the foliage. The insect was found also in the Washademoak and Jemseg areas.

**CODLING MOTH.**—Damage in the Okanagan and Kootenay, B.C., valleys was somewhat less than in 1951, when it was the greatest since the introduction of DDT in 1947. Favoured by weather conditions, increase occurred throughout Ontario, injury to apple being the greatest in several years; infestation on pear was generally light. The insect was reported to be a minor pest in Quebec. The population was somewhat reduced in the Gagetown, N.B., area, but in the Annapolis Valley, N.S., damage to apples was general and almost as severe as in 1951.

**CRANBERRY FRUITWORM.**—This insect continued to be the major pest of cranberries in New Brunswick. A plantation at Lower Escuminac was so severely infested that the owner did not attempt control; in 1951 he had dumped his crop into the sea. Infestations of 12 to 15 per cent were recorded in check areas of a demonstration bog at Grand Lake.

**CURCULIONIDS.**—The apple curculio, although a minor pest in Quebec, showed some signs of a population build-up in the St. Jean area. The plum curculio occurred in moderate numbers on plums at Morden, Man. In Ontario, infestation was heavier than usual on peach, plum, apricot, cherry, and apple. Although not ordinarily a serious pest of apple, it was particularly injurious in some orchards in Essex County and eastern Ontario. Severe losses occurred in neglected orchards in Quebec, but control measures were effective in commercial orchards. The strawberry weevil, generally distributed in Eastern Canada, was nowhere a serious pest in 1952. Light infestations were reported from Morden, Man., and light to moderate damage in the Quebec City, Montreal, and Bellechasse County districts of Quebec. In New Brunswick the weevil was unusually scarce in plantations in the Grand Lake, Washademoak, and Belleisle districts. Little fruit injury occurred in Nova Scotia and Prince Edward Island, probably because of successive treatments with DDT in recent years. The black vine weevil and the strawberry root weevil were, as usual, the major insect pests of strawberries in coastal areas of British Columbia. The black vine weevil appeared in outbreak numbers and destroyed some plantings in the Keating area on Vancouver Island. It appeared to be a more serious pest where sawdust was used as a mulch, and was not controlled with poisoned bait so readily as the strawberry root weevil. At Kamloops, B.C., large populations of undertermined root weevil larvae caused considerable damage in at least two fields of strawberries. The strawberry root weevil appeared to be increasing as a pest of strawberries in Manitoba, notably at Portage la Prairie and Morden. It was abundant in areas adjoining Lake Erie in Ontario and caused minor damage to strawberry plants in Prince Edward Island.

**CURRENT BORER.**—A light infestation occurred at Morden, Man.; and at St. Stephen, N.B., considerable damage was done in small gardens.

**CURRENT FRUIT FLY.**—Infestation was general in Saskatchewan and Manitoba, 70 to 100 per cent of black, white, and red currants being damaged in northeastern Saskatchewan where no insecticides were applied.

**EUROPEAN APPLE SAWFLY.**—This sawfly was of major importance to apple growers in the lower Vancouver Island area. Effective control measures have prevented any appreciable spread from the area in which it was observed for the first time in North America in 1940.

**EUROPEAN WINTER MOTH.**—This recently introduced species was present in moderate to serve infestations along the south shore of Nova Scotia, feeding extensively on apple foliage where not controlled.

**EYE-SPOTTED BUD MOTH.**—This orchard pest was not so serious a problem as in 1951 in the Okanagan and Kootenay, B.C., valleys, but many growers found it necessary to spray for it. Control measures were generally employed also throughout Eastern Canada, where the insect persisted in varying numbers. Infestation was moderate in eastern Ontario and light elsewhere in the Province. Threatening populations existed in all apple-growing areas of Quebec. Little change in status was noted in the Springhill and Keswick areas of New Brunswick. A survey in the Annapolis Valley, N.S., indicated a definite decrease in numbers as compared with 1951, but populations in some orchards had increased and damage remained comparatively heavy. Large populations and serious damage were reported also from Prince Edward Island.



**FRUIT TREE BORERS.**—The lesser peach tree borer continued to cause serious injury in many peach orchards in Essex County, Ont., but was less prevalent in the Niagara Peninsula. Conditions favourable for an increase of peach canker apparently were mainly responsible for increased populations of the borer. The peach tree borer was, as in 1951, of minor importance in British Columbia, and in Ontario the usual number of infestations required control measures. The peach twig borer caused much less damage than in 1951 in British Columbia, possibly because of post-blossom DDT sprays. The roundheaded apple tree borer continued to be a major threat to young apple trees in Quebec, and was common in young orchards in Charlotte County, N.B. Several cases of severe attacks on peach trees by adults of the shot-hole borer were reported in Norfolk County, Ont. This borer was present also on dead and dying apple trees in the Vineland, Ont., area, but appeared to be outnumbered by the larger shot-hole borer.

**FRUITWORMS.**—Severe infestations of the fall cankerworm occurred on fruit trees in the Morden and Winnipeg areas in Manitoba, and it was again present in outbreak numbers in parts of Hants County, and in increased numbers in parts of Kings County, N.S. The spring cankerworm decreased to minor importance at St. Jean, Que., after local outbreaks in 1951. A moderate increase in cankerworm populations was apparent where control measures were inadequate in Ontario. Green fruitworms, *Graptolitha*, spp., maintained the major status reached in 1951 in the St. Jean, Que., area. An increase in injury to apples occurred in Nova Scotia, where a survey of the Annapolis Valley revealed an average of 3.6 per cent fruit injury, and a series of bait pan captures of adults yielded 75 per cent *Graptolitha bethunei* (G. & R.) and 11 per cent *Xylena nupera* (Lint.), and smaller numbers of six other species. A light infestation of the lesser appleworm occurred at Morden, Man. (See also "Raspberry Fruitworms".)

**GRAPE BERRY MOTH.**—This grape pest caused moderate damage in most vineyards in Essex County, Ont., and appeared to be more numerous than usual in the few Niagara vineyards in which it had been troublesome for years.

**GRAPE FLEA BEETLE.**—For the first time in many years this beetle caused serious injury in some Ontario vineyards.

**IMPORTED CURRANTWORM.**—Currant bushes were seriously defoliated in the Bindloss, Alta., district; at Saskatoon, Parkside, and Glenside, Sask.; and in Newfoundland. Gooseberries were severely damaged throughout Prince Edward Island, where the insect was more numerous than usual.

**LEAFHOPPERS.**—The grape leafhopper was of minor importance in Ontario, where control measures have been effective in recent years. An unusually severe infestation of the rose leafhopper caused noticeable injury on prune and Damson plum in an orchard at Vineland Station, Ont., and in Nova Scotia the white apple leafhopper was present only in small numbers in most orchards.

**LEAF ROLLERS.**—Apparently still increasing in the Okanagan and Kootenay, B.C., valleys, the fruit tree leaf roller was more injurious than in 1951. In Ontario and Quebec it was of minor importance. Attacking peaches for the first time on record, the orange tortrix was observed on Elberta and Vedette varieties in the Oak Bay, B.C., district on Vancouver Island. An undetermined leaf roller was very prevalent on apple foliage and to a lesser extent on strawberry in Alberta. In Ontario the red-banded leaf roller was less prevalent than in 1951 in all apple-growing areas except the Georgian Bay district, where it appeared to be increasing. Moderate to severe infestations were reported in southern Quebec. Several leaf rollers were common on apple in the Annapolis Valley, N.S. Of these the gray-banded leaf roller caused the most damage; it occurred generally, and in some orchards was a major pest. *Archips persicana* (Fitch) and *Pandemis limitata* (Rob.) were present in considerable numbers but caused only minor injury. The oblique-banded leaf roller continued to be comparatively scarce. Large numbers of the strawberry leaf roller caused some damage at Vantage, Sask., and moderate injury was reported in Newfoundland. Ontario reported no serious infestations.

**MITES.**—The European red mite was more troublesome than in 1951 in British Columbia, notably in the Summerland district and the Kootenay Valley. In Ontario it was generally less abundant than usual, and less numerous than for several years on peach, plum, and sour cherry in the Niagara Peninsula. In the Oakville, Ont., area, however, it was more prevalent on apple than in 1951. Populations remained at a relatively low level in the St. Jean area and damage was much less than in 1951 in the St. Anne de la Pocatiere area, Que., but in many other areas of the St. Lawrence River Valley little change in status was noted. Populations remained at relatively low levels in Nova Scotia, except where predators were destroyed by insecticides, and in Prince Edward Island infestation was lighter than in 1951. The two-spotted mite caused very little damage in British Columbia in 1952. In Ontario a late-season population build-up of this species and *Septanychus canadensis* McG. caused severe injury in a few apple orchards in the Niagara and Burlington-Bronte areas; generally distributed populations of the two-spotted mite in peach orchards caused little injury. A few outbreaks of the last-named species occurred on strawberry in southwestern Ontario, and in the Bradford Marsh area this host was severely infested, somewhat less severe infestations occurring on raspberry. The species was common in Quebec, being found as far north as the Lake St. Jean area, but was of minor importance. In Nova Scotia it was observed only in a few orchards and in small numbers. As in 1951, the pear leaf blister mite was present in medium to severe infestations in a number of orchards, probably because of ineffective control measures. Lime-sulphur sprays reduced populations in the Niagara, Ont., area to minimum proportions, but in Norfolk County, Ont., this mite was more prevalent than in 1951. The Pacific mite was of minor importance in British Columbia, but, along with *Eotetranychus mcdanieli* (McG.), caused considerable damage to raspberry and currant at Sidney, Morden, and Winnipeg, Man., and Lemberg, Sask. A predacious mite, *Typhlodromus* sp., occurred in numbers in association with these species. In the Okanagan and Kootenay, B.C., valleys, *Eotetranychus carpini borealis* (Ewing) [= *E. flavus* (Ewing)], a yellow spider mite, was more troublesome than in 1951, causing considerable damage to McIntosh and Delicious apple trees in the Creston area. The species was not known to occur in other areas of the Province. *Phyllocoptes* spp. were more numerous than in 1951, notably on peach, but no serious injury resulted. In Saskatchewan unspecified mite species damaged strawberry plants at Parkside, and raspberries at Davidson. The clover mite occurred at Morden, Man., and was numerous in several orchards in Nova Scotia but caused little damage.

**NITIDULIDS.**—Although well below the peak numbers of 1949, these insects were destructive to raspberry in the Chatham, Ont., area.

**ORIENTAL FRUIT MOTH.**—In Essex County, Ont., infestation remained at a low level and less than one per cent of the peach fruit was injured. In the Niagara Peninsula there was a considerable increase over 1951. Fruit injury on Jubilee, V varieties, and Elberta peaches averaged 6.1, 4.6, and 2.4 per cent respectively. More frequent rains in the Niagara district than in Essex County may have been responsible for the increase of the moth in the former area. Injury on Kieffer pear was generally light.

**PEAR-SLUG.**—This insect occurred in outbreak form in several pear and cherry orchards in the south Okanagan, B.C., area, causing extensive damage. At Medicine Hat, Alta., it attacked sandcherry-plum hybrids. Injury was light in Ontario, and in Newfoundland, where it had been observed for the first time in 1951, it was found only in one back yard at St. John's West.

**PLANT BUGS.**—*Lygus* spp. were less troublesome than usual on peach, apple, and pear in British Columbia. The caragana plant bug was reported to have destroyed a raspberry plantation at Mervin, Sask. The tarnished plant bug seriously damaged strawberry beds in the Morden, Man., area, and was troublesome on nursery stock in Norfolk County, Ont. Catfacing of peaches was much less than in 1951 in Ontario. Only a few orchards had more than a trace of *Neolygus communis novascotiensis* Knight in Nova Scotia, but *Campylomma verbasci* (Meyer) occurred in moderate numbers in some orchards, causing minor damage to fruit.

**RASPBERRY CANE BORERS.**—The raspberry cane borer was common on raspberry and blackberry throughout Quebec, and 50 per cent infestation was not unusual in the St. Jean area. *Oberia* sp. was reported at Winnipeg, Man. *Oberia affinis* Lerg was moderately common on raspberry and occurred on some species of thimbleberry and rose in eastern Ontario. It was rather more common than in 1951 in New Brunswick. In Alberta many reports were received of damage to raspberry canes by an aegeriid believed to be *Bembecia marginata* (Harr.); a grower in Edmonton reported 50 per cent infestation of canes.

**RASPBERRY FRUITWORMS.**—Fruit bud injury in raspberry and loganberry plantings in the lower mainland areas of British Columbia was not of serious economic importance, most growers having applied one dust application for control. *Byturus bakeri* Barber was the only species present. *Byturus* sp. caused moderate damage at Assiniboia, Rowletta, and Saskatoon, Saskatchewan.

**RASPBERRY ROOT BORER.**—This borer has increased for three successive years in coastal areas of British Columbia, and 50 per cent infestation was recorded in some raspberry and loganberry plantings in 1952. Considerable cane infestation by this species was reported from Alberta.

**RASPBERRY SAWFLY.**—Damage in three plantations in Saskatoon, Sask., was reported, and a light infestation occurred at Morden, Man.

**ROSE CHAFER.**—This beetle continued to cause injury in fruit orchards, raspberry plantings, vineyards, and flower gardens in sandy areas of Essex County, Ont. Severe infestation was recorded in the Windsor and Strathroy, Ont., areas. Considerable numbers appeared also in several orchards in southwestern Quebec.

**SCALE INSECTS.**—The oystershell scale has remained at low population levels in fruit-growing areas of British Columbia for several years. It was of little economic importance also in commercial orchards in Eastern Canada in 1952, control measures being effective where necessary. The San Jose scale was more abundant than in 1951 in the Okanagan and Kootenay, B.C., valleys, and a serious problem in the Oliver, Osoyoos, and Keremeos areas. Only light, scattered infestations were reported in Ontario. Soft scales, *Lecanium* sp. and *Pulvinaria* sp., also were more troublesome on peach and apricot than in 1951 in British Columbia; populations have been increasing for several years, notably from Summerland south to the International Boundary. A severe infestation of the scurfy scale was observed on Siberian crabapple at Niverville, Man., and moderate infestations occurred on crabapple, apple, and pear at Morden, Man. Appearance of the cottony maple scale on grape in a nursery at St. John's, Nfld., constituted the first record of this scale in the Province.

**STRAWBERRY CROWN MOTH.**—This insect continued to cause concern to strawberry growers in British Columbia, some three-year-old plantings having up to 50 per cent infestation of plants.

**TENT CATERPILLARS AND WEBWORMS.**—Both the forest and the eastern tent caterpillars were abundant in fruit orchards in the Georgian Bay, Ont., area, and at St. Jean, Que.; they were fairly common in New Brunswick, and although the outbreak in Nova Scotia was somewhat less severe than in 1951, control measures were necessary in many orchards. The eastern tent caterpillar caused extensive and severe defoliation in orchards throughout eastern Ontario where not controlled by sprays. In southwestern British Columbia, populations of the western tent caterpillar, which had continued to decline since the peak year of 1946, showed some signs of increase in 1952. The ugly-nest caterpillar continued to appear in outbreak numbers in the St. Jean, Que., area, and *Hyphantria textor* Harr. continued to be scarce in Nova Scotia.

**THRIPS.**—Thrips have increased to such an extent in McIntosh apple orchards in the Kootenay and Okanagan, B.C., valleys that special control measures are likely to be necessary in 1953. *Frankliniella vaccinii* Morgan was prevalent on blueberry in many commercial crops in Charlotte County, N.B., but infestations were generally less severe than in recent years. Infestations were recorded also in other parts of the Province.



**PREDATORS OF ORCHARD PESTS.**—In Nova Scotia there were variations in the abundance of some of the predators of orchard pests, but in general the predator situation remained much the same as in 1951. Of the two predacious thrips present, *Haplothrips faurei* Hood was much more numerous and widespread than *Leptothrips mali* (Fitch). *H. faurei* probably occurred in more orchards and in greater numbers than in 1951. *L. mali* was only observed in a few orchards and seemed somewhat scarcer than in 1951. The most commonly found predacious mirids and anthocorids were *Hyaliodes harti* Knight and *Anthocoris musculus* Say. *H. harti* occurred more generally and in greater numbers than in 1951. *A. musculus* showed a decline in numbers. Other predacious mirids and anthocorids were scarce. There was little if any increase in *Deraeocoris nebulosus* (Uhl.) and *D. fasciolus* Knight was scarcer. The predacious mites, *Typhlodromus* spp., which prey on the European red mite and other mites, were general and were found in about the same numbers as in 1951. Coccinellids also were general and occurred in about the same numbers as in 1951. *Stethorus* sp. was somewhat scarcer than in 1951. Aphid-lions were fairly abundant but syrphid flies were not as numerous as usual.

### INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

**APHIDS.**—Severe infestations of aphids, probably mainly the caragana aphid, occurred on caragana in the East Kootenays, B.C. Infestation was general in Alberta, 100 per cent defoliation occurring in many southern districts, notably at Lethbridge, Pincher Creek, Calgary, and Medicine Hat. In Saskatchewan also, aphids were unusually abundant on caragana, causing severe defoliation in the Conquest, Beechy, and Kenaston areas, south and west of Saskatoon. Rose bushes, tomatoes, Manitoba maple, gladioli, asters, and house plants were damaged by aphids at Saskatoon. Delphiniums were commonly attacked at Brandon, Man. Near Harrow, Ont., aphids were abundant on ornamentals, notably willow; and at Leamington, Ont., the melon aphid was troublesome in several greenhouses.

**BLACK-HEADED FIREWORM.**—An outbreak of this insect on holly in southwestern British Columbia was controlled by DDT.

**BLACK VINE WEEVIL.**—This insect killed *Taxus* plants in ornamental plantings in some Ontario nurseries.

**BOXELDER BUG.**—Pistillate boxelder was commonly attacked by the boxelder bug in southwestern Ontario.

**CABBAGE LOOPER.**—Foliage feeding by this insect on tomato was common in greenhouses in the Harrow, Ont., area.

**COLUMBINE INSECTS.**—The columbine borer was reported from Oakville, Ont., and the columbine leaf miner occurred at Marmora, Ont.

**CORN EARWORM.**—Although not abundant, this insect fed on tomatoes in greenhouses in southwestern Ontario, causing some concern.

**FOUR-LINED PLANT BUG.**—Flowers and border plants were commonly injured by this plant bug along the shore of Lake Erie, Ont.

**GARDEN CENTIPEDE.**—A serious infestation of this species occurred in a greenhouse at Medicine Hat, Alta.

**GREENHOUSE WHITEFLY.**—Tomatoes in greenhouses were commonly attacked by this species at Winnipeg, Man., and Harrow, Ont.

**HOLLY LEAF MINER.**—Infestation of holly by this species in British Columbia was reduced to a minimum by two sprays of 25 per cent DDT concentrate.

**LEAFHOPPERS.**—*Erythroneura* sp., probably *ziczac* Walsh, commonly attacked Virginia creeper at Kamloops and Vernon, B.C., and at Dunfermline, Scott, and Saskatoon, Sask. *Macrosteles* sp. caused local damage to lawn grass at Saskatoon, Sask.; at Charlottetown, P.E.I., many rose bushes and some elm and other ornamental tree were attacked by leafhoppers.

**LILAC INSECTS.**—The lilac borer was reported from several localities in the Winnipeg, Man., area. The lilac leaf miner occurred in the Vernon, B.C., area, and was reported to be common throughout most of Eastern Canada. Damage was more conspicuous than usual in eastern Ontario, very general in southern Quebec, somewhat below average in Prince Edward Island, and still increasing in Newfoundland.

**MITES.**—In Saskatchewan greenhouses, strawberries were severely injured by mites at Parkside, raspberries at Davidson, and delphinium at Saskatoon; reports were less numerous than in 1951. The tomato russet mite, recorded for the first time in Essex County, Ont., damaged tomatoes in a greenhouse near Harrow. The two-spotted mite commonly attacked greenhouse crops, and deciduous shrubs and flowers in southwestern Ontario. Greenhouse carnations were extensively damaged in the Lincoln, N.B., area.

**NARCISSUS BULB FLY.**—During the past five years this insect does not appear to have been influenced by either weather or parasites; infestations as high as 60 per cent continued to appear in unsprayed and weedy plantings in southwestern British Columbia.

**NYMPHALIDS.**—*Vanessa caryae* Hbn. occurred on hollyhock at Lethbridge, Alta., farther inland than usual. *V. cardui* (L.) caused minor damage to hollyhock at Carnduff and Canora, Sask., and Morden, Man. It occurred on dahlias at Winnipeg, Man. *V. virginiensis* (Drury) damaged hollyhock at Fredericton, N.B.

**A PSYLLID.**—A moderate infestation of *Psylla tuthilli* (Cald.) was recorded on *Shepherdia argentea* Nutt. at Morden, Man.

**ROSE CHAFER.**—Roses, oriental poppies, and other ornamentals were extensively damaged in the sandy areas of Essex County, Ont., bordering Lake Erie and the Detroit River. Infestation was severe in the Windsor and Strathroy, Ont., areas.

**ROSE CURCULIO.**—Scattered occurrences were reported from Saskatoon, Shellbrook, and Esterhazy, Sask., and Morden, Man.; infestation was generally light in both provinces.

**SCALE INSECTS.**—The juniper scale caused some damage to ornamental juniper, notably at Pfitzer, Ont. The oystershell scale and the scurfy scale were both troublesome on lilac, willow, and other ornamentals in southwestern Ontario.

**SLUGS.**—Appreciable injury to ornamentals, particularly low, flowering plants, was reported from Ontario and New Brunswick.

**THRIPS.**—The gladiolus thrips caused moderate to severe damage to gladioli at Scott, Kindersley, Theodore, and Saskatoon, Sask.; and at Arden and Winnipeg, Man. Infestation occurred commonly in Eastern Canada where adequate control measures were not carried out. The onion thrips was present in minor infestations in several greenhouses near Harrow, Ont., during the spring.

**EASTERN TENT CATERPILLAR.**—Ornamental plants and shade trees were commonly defoliated by this species throughout eastern Ontario and southern Quebec.

#### INSECTS ATTACKING MAN AND LIVESTOCK

**BED BUG.**—A few infestations were recorded at Kamloops and Vernon, B.C.; one at Lethbridge, Alta.; one each at Lafleche and Saskatoon, and two at Prince Albert, Sask.; one from Manitoba; eight from Ottawa and Toronto, Ont.; a few in southwestern Ontario; and one from Les Etroits, Que.

**BLACK FLIES.**—Populations were apparently below average in British Columbia. *Simulium arcticum* Mall. and *Cnephia taeniatifrons* (End.) were less abundant along the Saskatchewan River than in recent years, and there were no livestock losses. From Hillside, Sask., came the only report of an outbreak of *S. arcticum*. Elsewhere on the prairies, where black flies were abundant locally they caused some irritation to livestock and man: *S. venustum* Say and *S. vittatum* Zett. along the northern and western fringes of settlement in Saskatchewan and Alberta, *S. griseum* Coq. in the Milk River drainage area in southern Alberta, and *S. venustum*, *S. meridionale* Riley, and *S. luggeri* N. & M. in the Battle River Valley in Saskatchewan. Larvae of *S. venustum* were very numerous in the Souris River, Man., but were effectively controlled. A severe outbreak of *Simulium* sp. caused great inconvenience and discomfort to man and animals in central Hastings County, Ont., during late May and early June. Species of this genus were very numerous also in Newfoundland.

**BLACK WIDOW SPIDER.**—There were numerous requests for information from the Kootenay, Trail, and Okanagan, B.C., districts but no reports of bites were received.

**BLOW FLIES AND FLESH FLIES.**—No new cases of myiasis in humans were reported in British Columbia but maggot infestations on dehorned cattle were reported from the Kootenay area. Blow flies were unusually common in the Saskatoon, Sask., area, the most numerous species being *Phaenicia sericata* (Mg.), *Cynomyopsis cadaverina* (R.-D.), and *Lucilia illustris* (Mg.); one case of nasal myiasis in a human was reported from Redvers, Sask. Several larvae of *Calliphora livida* Hall were found in an unusual location: under the edge of a rug close to the fireplace in an Ottawa dwelling; they were believed to have developed on a dead bird in the chimney.

**BOT FLIES.**—Autopsy of a deer's head at Kamloops revealed 115 larvae of *Cephenomyia* sp., an indication of the prevalence of this pest. Horses in Manitoba were reported to be heavily infested with *Gasterophilus* spp.

**CATTLE GRUBS.**—*Hypoderma* spp. persisted in more or less normal numbers in British Columbia. A campaign in Manitoba effected a large measure of control but, as in most cattle-raising areas of Canada, untreated small herds maintained foci of infestation. For some unknown reason cattle grubs were not present in the southern part of the Red River Valley.

**FLEA.**—Reports of *Ctenocephalides* spp. in the Ottawa area were much more numerous than in 1951, and several reports were received from other points in Eastern Canada. The European chicken flea was reported from Carievale and Langbank, Sask., children having been attacked on several occasions at the former locality.

**HORN FLY.**—No outbreaks of the horn fly were reported in northern Alberta although severe infestation had occurred in 1951. Normal numbers were observed in Prince Edward Island. At Ottawa a horn fly occurring indoors persistently attacked and finally bit a young girl.

**LEECHES.**—Bathers were reported to have been commonly attacked by leeches in Mississippi Lake, Ont.

**MITES.**—An infestation of chiggers was reported in the Ottawa area, and *Sarcoptes scabiei* (Deg.) occurred on hogs near Winnipeg, Man.

**MOSQUITOES.**—No unusual outbreaks of mosquitoes were reported in British Columbia. In northern Alberta they were a source of annoyance throughout the summer as a result of frequent rains but were never unusually abundant. *Anopheles* spp. were more numerous than usual late in the season. Mosquitoes appeared unusually early in Saskatchewan and were a serious pest throughout the Province during May, June, and July. In Manitoba *Aedes spencerii* (Theo.) occurred in moderate numbers early in the season. *Aedes vexans* (Meig.) appeared unusually late as a result of drought conditions, large flights occurring in September and early October. In southwestern Ontario infestation was the most severe in four years. Populations were large in southern areas of eastern Ontario but were reduced from those of 1951 as a result



of very dry weather in May. Frequent rains in the Ottawa River Valley maintained populations at a high level throughout the greater part of the summer. Thirteen species were collected in a survey of the National Park area of Prince Edward Island. Recent experimental work with radio-active tracers has revealed the following predators to be of importance in the control of mosquitoes in Canada: larvae of predacious mosquitoes, adults and larvae of water beetles, adults and nymphs of water bugs, damselfly and caddisfly larvae, and pond snails.

**SHEEP-TICK** (Sheep Ked).—This insect continued to be an important parasite of sheep in the Kamloops, B.C., area, where untreated flocks are believed to reinfest sprayed flocks on summer ranges annually.

**SNIPER FLIES**.—*Symphoromyia atripes* Bigot continued to cause annoyance in British Columbia park areas at altitudes above 4,000 feet.

**TABANIDS**.—Normal populations in the Kamloops, B.C., area occasioned no unusual comment. In the northern agricultural areas of Saskatchewan tabanids were a serious pest, at least 11 species being common in the area. *Tabanus septentrionalis* Loew was a moderate pest in southern areas of the Province. *Tabanus* spp., increasing in Hastings County, Ont., in recent years, reached peak numbers in 1952, *T. affinis* Kby. predominating; *Chrysops* spp. were moderately abundant, particularly in forested areas. *Tabanus* spp. were normally troublesome and *Chrysops* spp. more numerous than usual in Newfoundland.

**TICKS**.—*Dermacentor andersoni* Stiles appeared to be less abundant than usual in the Kamloops, B.C., area; cases of tick paralysis in livestock were rare, and collecting yielded few specimens. Drought conditions in 1951 were believed to have been associated with the scarcity. *Dermacentor albipictus* (Pack.) was unusually abundant; several reports of severe infestation on moose were received from the British Columbia Game Department, and large numbers of young were observed about moose carcasses in the fall. A female of this species was removed from an Indian at Blue Ridge, Alta. *Ixodes pacificus* C. & K. was troublesome at Pender Harbour, B.C. but at Harrison Bay, where it had usually been abundant, collections were small. *Dermacentor variabilis* (Say) commonly attacked humans, cattle, horses, and dogs in Manitoba; it was taken on children and a dog at Pendleton, Ont. *Ixodes cookei* Pack. was taken on a child in the Ottawa area.

**WASPS AND BEES**.—Wasps were commonly a household nuisance at Vernon, B.C., and for the second successive year nests of *Vespa* spp. were unusually abundant about urban dwellings in northern Alberta. In Manitoba species of *Vespa* were less numerous than in 1951. *Vespula vulgaris* (L.) has not been abundant in Newfoundland since the outbreak in 1950. A "village" infestation of the social bee *Andrena asteris* Robt., disfigured a lawn at Toronto, Ont.

#### HOUSEHOLD INSECTS

**ANTS**.—Ants of various species continued to be among the more troublesome household pests, and frequently caused damage to lawns and golf courses throughout Canada. Over 60 reports of *Camponotus* spp. were received at Ottawa from points in Eastern Canada, and many more were received at regional laboratories. The pharaoh ant occurred frequently in buildings in several urban centres in Eastern Canada, occasionally overrunning large office and apartment buildings and spreading into surrounding areas. The odorous house ant, rarely reported previously in Canada, occurred in several dwellings in Victoria, B.C., and in an Ottawa home. The cornfield ant invaded an apartment building at Ottawa, and the larger yellow ant was taken in a dwelling at Hamilton for the first record in Canada.

**AQUATIC INSECTS**.—Insecticide-conscious residents of urban centres bordering large rivers and lakes in Eastern Canada are becoming increasingly concerned over the annual invasions of caddisflies, mayflies and chironomids, which cluster at lights, settle on buildings, and have been blamed for certain respiratory ailments among the residents. At Ottawa chironomids entered operating rooms in a local hospital through standard mesh screens and interfered with normal activities.

**BAGWORMS.**—Numbers of *Solenobia* sp., probably hibernating, collected at windows in a Toronto dwelling. Bagworms ordinaly live on the bark of trees.

**BOXELDER BUG.**—This insect was unusually abundant in central and southwestern areas of Ontario, where dwellings were commonly invaded.

**CARPET BEETLES.**—Several infestations of the black carpet beetle were reported at the Vernon, B.C., laboratory. It was a major household pest in urban centres of northern Alberta, and was more commonly reported than clothes moths in Saskatchewan and Manitoba, and throughout Eastern Canada. In Ontario it was recorded as far north as Timmins. Stocks of nylon hosiery were damaged in a plant at Kingston, Ont. *Anthrenus scrophulariae* (L.), which occurs much less commonly, was taken in a few homes at Ottawa and was recorded at Moncton and Mouth of Keswick, N.B. *Anthrenus verbasci* (L.) was recorded only at Vernon, B.C., and an entire house at Edmonton, Alta., was severely infested by *Anthrenus flavipes* Lec., which had been brought from Missouri, U.S.A., in furniture. This was believed to be the first record of *Anthrenus* spp. in Alberta.

**CHLOROPIDS.**—Adults were more abundant than usual at windows in buildings in Alberta; at Edmonton immense numbers collected in a shop window illuminated by a very bright neon light. Large numbers occurred also in dwellings at Guelph and Penetanguishene, Ont.

**CLOTHES MOTHS.**—Reports from points in Eastern Canada were moderately numerous; in Western Canada they were comparatively scarce.

**CLUSTER FLY.**—This insect was a greater nuisance than usual in rural and suburban dwellings in eastern Ontario and southwestern Quebec during the spring, and during the fall reports were numerous in the Ottawa Valley area. Large populations are believed to be associated with frequent rains.

**COCKROACHES.**—The German cockroach was commonly reported from Manitoba eastward to Newfoundland; an infestation at Alert Weather Station, Ellesmere Is., N.W.T., created a new northerly record for this insect. The oriental cockroach occurred in a warehouse at Winnipeg, Man. Considerable numbers of the American cockroach were found in a shipment of art forwarded from Washington, D.C., to Ottawa, and *Parcoblatta pennsylvanica* (Deg.) occurred commonly in cottages and motels in Hastings County, Ont.

**CRICKETS.**—Camel crickets, *Ceuthophilus* sp., occurred commonly in basements of new houses in Alberta, and were frequently reported at Ottawa. The field cricket was a common pest in dwellings and apartments in a suburban area of Ottawa.

**CURCULIONIDS.**—The strawberry root weevil was reported to be an occasional pest in dwellings and other buildings in many districts from Saskatchewan to Newfoundland, and was very abundant in areas along Lake Erie in Ontario. Adults of the black vine weevil invaded an Ottawa dwelling.

**EUROPEAN EARWIG.**—This insect reached Walkerton and Durham in the course of its spread in south-central Ontario.

**GROUND BEETLES.**—*Stenolophus conjunctus* (Say) occurred in nuisance numbers in a dwelling at Renfrew, Ont., and *Spongopus verticalis* Lec. in an Ottawa home.

**HOUSE CENTIPEDE.**—Three occurrences at Ottawa and one at Yamachiche, Que., were recorded.

**HOUSE FLY.**—Noticeably larger populations were reported at Saskatoon, Sask., and a low level of abundance continued in Manitoba. Few reports on this common pest were received.

**MASKED HUNTER.**—Specimens were received from Peterborough, Ont.; and a resident of Poltimore, Que., reported the presence of large numbers in vermiculite insulation. The occurrence of more than a few specimens in a dwelling is unusual.

**MITES.**—Reports of invasion of buildings by the clover mite were numerous at Lethbridge, Fort Macleod, and Warner, Alta. One such report was received from Saskatchewan, and two each from Manitoba and Ontario. An invasion of the chicken mite occurred in an Ottawa dwelling, and at Belleisle Creek, N.B., *Cheyletus eruditus* Schr. and *Haemolaelaps megaventralis* Strand, infested a dog's bedding consisting of straw and chaff.

**A MUSCID** (n. rec.).—A severe infestation of *Musca autumnalis* Deg. [= *M. corvina* F.] occurred in the wall spaces and interior of a church at Middleton, N.S. The species had not previously been recorded in North America. The larvae develop in cow manure, and the adults feed on the exudations from wounds on animals. In autumn the adults congregate in buildings to hibernate in much the same manner as the cluster fly.

**SEWAGE FLIES.**—Several occurrences of *Psychoda* sp. were reported at Ottawa.

**SILVERFISH.**—Silverfish and firebrats were commonly reported from urban centres throughout Canada, and at Ottawa samples of dried milk were found to contain numerous fragments of these species.

**SPIDER BEETLES.**—*Mezium affine* Boiel. infested a dwelling at Ottawa, and an under-terminated species was numerous in a house at Wabana, Nfld.

**TENT CATERPILLARS.**—*Malacosoma* spp., seeking pupation sites, occurred in large numbers about dwellings in the Ottawa area, creating a considerable nuisance. Reports were received also of the abundant parasite *Sarcophaga aldrichi* Park. soiling clothing hung out to dry and alighting frequently on humans.

**TERMITES.**—Extensive damage to a dwelling was reported from Ashcroft, B.C., and many reports were received from Toronto, Ont.

**A TINEID** (n. rec.).—Adults of *Monopis ferruginella* Hbn., somewhat resembling clothes moths except for their black colour, occurred in thousands in a dwelling at Vancouver, B.C. This is the first North American record of the insect. It occurs commonly about dwellings in Europe, the larvae developing on fungi associated with decaying vegetable matter.

**WINDOW FLY.**—Larvae of *Scenopinus fenestralis* L., a beneficial predator of indoor insects, were recorded from dwellings at Ascot Corners, Que., and Foxboro, Ont.

**WOOD BORERS.**—Powder-post beetles, mainly *Anobium punctatum* (Deg.), caused extensive damage in barns and houses in Ontario; furniture, as well as hardwood flooring and structural timbers, was attacked. In one instance damage resulted in the collapse of barn flooring and the death of livestock. Reports of damage were numerous also in Newfoundland.

#### STORED PRODUCT INSECTS

**STORED GRAIN INSECTS.**—No serious outbreaks of pests of stored grain were reported in Canada until about the end of September, when the rusty grain beetle, *Laemophloeus ferrugineus* (Steph.), was reported in low-grade wheat of the 1950 crop in Saskatchewan. During the following five weeks 14 elevator points in the Province reported similar infestations. Subsequently, numerous reports were received of infestations in farm-stored grain of the 1952 crop in Alberta; considerable heating and spoilage were associated with the infestations. Every effort was made to confine and eliminate the infestations before serious damage was done. Other stored grain pests were of comparatively minor importance.

Elevators in Eastern Canada remained essentially free from insects. Light infestations, particularly of the Mediterranean flour moth, the yellow mealworm, the black carpet beetle, and mites occurred at some points but they were satisfactorily controlled. The usual amount of damage in farm granaries was reported, the most common pests concerned being the saw-toothed grain beetle, the confused flour beetle, and the flat grain beetle.



BEAN WEEVIL.—Minor local infestations in dried beans were reported from Ontario, Quebec, and New Brunswick.

CADELLE.—This insect was an incidental pest in flour and feed establishments in the Prairie Provinces.

CHEESE SKIPPER.—Large numbers of this species occurred in a tannery at Winnipeg, Man.

CIGARETTE BEETLE.—Reported infestations included a chesterfield at Ottawa, and a dwelling at Verdun, Que.

CONFUSED FLOUR BEETLE.—This insect was one of the two most troublesome insects found in prairie flour mills, and it occurred commonly in pantry infestations in all provinces. In Eastern Canada it was one of the three most common insect pests in farm granaries.

A CUCUJID (n. rec.).—An infestation of *Oryzaephilus mercator* (Fauv.) occurred on insect specimens in the National Collection at Ottawa, the first Canadian record.

DRUG-STORE BEETLE.—Occasional complaints concerning this beetle in bakeries and dwellings were received from Saskatchewan eastward to the Atlantic.

FLAT GRAIN BEETLE.—This beetle was one of the most troublesome insects in prairie flour mills, and in farm granaries in Eastern Canada.

FOREIGN GRAIN BEETLE.—*Ahasverus advena* (Waltl.) was encountered in a few grain samples in the Prairie Provinces.

GRANARY WEEVIL.—Infestations of this weevil occurred in United States corn stored at the Pacific coast in Canada, and it was an occasional pest of flour and feed stores in the area. Minor numbers were reported in Ontario farm granaries.

GRAIN MITES.—Stored grain, mainly wheat, in elevators at Lethbridge, Barnwell, Stavely, and Turin, Alta., became infested with mites, and some occurrences in farm-stored grain were reported from both Alberta and Saskatchewan.

HIDE BEETLE.—An infestation in a tannery at Winnipeg, Man., was reported.

HOUSE MOTHS.—*Endrosis lacteella* (Schiff.) and *Hofmannophila pseudospretella* (Staint.) occurred at Vancouver, B.C.

INDIAN-MEAL MOTH.—Occasional reports were received from bakeries and home owners in various parts of Canada, and in British Columbia an infestation developed in United States corn stored at coastal points.

LARDER BEETLES.—*Dermestes lardarius* L. occurred commonly in dwellings, stores, and warehouses, and more reports than usual were received from points in Ontario and Quebec. *Dermestes ater* Deg., rarely recorded, was reported to have occurred in several homes at Brockville, Ont.

MEDITERRANEAN FLOUR MOTH.—Prairie flour mills, and warehouses and feed establishments on the Pacific coast, in the Prairie Provinces, and elsewhere were occasionally infested by this moth. It occurred also in United States corn stored at coastal points in British Columbia.

MEAL MOTH.—This insect was an incidental pest in flour and feed establishments on the Pacific coast.

ODD BEETLE.—An occurrence of *Thylodrius contractus* Mots. in an insect collection at the University of Manitoba was believed to be the first record in the Province.

A PYRALID (n. rec.).—The occurrence of considerable numbers of *Aphomia gularis* Zell. in a flour warehouse and a bakery in Vancouver, B.C., established a new record in Western Canada. An occurrence at Montreal in 1934 is the only previous record in Canada. Larvae fed on corn flour, and nuts at Vancouver.

**SAW-TOOTHED GRAIN BEETLE.**—This insect continued to be possibly the most frequently recorded pest of stored food materials in dwellings throughout Canada, and in addition was a common pest in farm granaries.

**SPIDER BEETLES.**—*Ptinus ocellus* Brown continued to be an important warehouse pest on the Pacific coast. In the Prairie Provinces a few grain samples contained *Ptinus villiger* (Reit.). *Niptus hololeucus* (Fald.) was recorded once in Saskatchewan.

**A TENEBRIONID.**—*Cynaesus angustus* Lec., first reported in Canada at Diana, Sask., in 1944, occurred in a general infestation on cereal products in a mill at Medicine Hat, Alta.

**TOBACCO MOTH.**—An outbreak of this species in stored bags of peas at Montreal, Que., was reported.

**YELLOW MEALWORM.**—This mealworm was an incidental pest in flour and feed buildings in coastal areas of British Columbia and in farm granaries throughout Canada. Occasional reports of adults being numerous in dwellings were believed to be, in some cases, a result of the attraction of lights to beetles occurring outdoors.

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# PROCEEDINGS OF THE EIGHTY-NINTH ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF ONTARIO

ONTARIO AGRICULTURAL COLLEGE, GUELPH, ONT.

OCTOBER 16 and 17, 1952

The Eighty-Ninth Annual Meeting of the Entomological Society of Ontario was called to order by the President, George F. Manson, at 10:00 a.m. October 16 in War Memorial Hall. During the following two days the President, Vice-President B. N. Smallman, and A. W. A. Brown presided over the presentation and discussion of some 15 invitation and submitted papers. At the reception and banquet in the Elizabeth Room of the Royal Hotel on the evening of the 16th Dr. K. W. Neatby, Director of Science Service, gave an illustrated talk on "Agricultural Research in Australia".

At the business meeting during the morning of the second day, the report of the Secretary-Treasurer was read and the financial statement presented. The following Committee reports were presented and passed.

## FINANCIAL STATEMENT

for

Year Ending October 31, 1952

### RECEIPTS

Dues .....	\$ 1004.63
Government Grant .....	300.00
Subscriptions .....	15.80
Back Numbers .....	17.95
Miscellaneous .....	53.41
	-----
	\$ 1391.79
Bank Balance	
31 Oct., 1952 .....	\$1093.71
Less cheques outstanding	
31 Oct., 1952 .....	91.00
	-----
	\$ 1002.71
	-----
	\$ 2394.50

Audited and found correct,

31 October, 1952

R. C. COOKE

C. J. PAYTON

### EXPENDITURES

Printing The Can. Ent. ....	\$ 883.20
Library .....	407.78
Bank Exchange .....	12.85
Stationery & Supplies .....	72.13
Postage .....	74.98
Miscellaneous .....	27.30
	-----
	\$ 1478.24
Less outstanding cheques	
31 Oct., 1952 .....	17.05
	-----
	\$ 1461.19
Bank Balance	
31 Oct., 1952 .....	933.31
	-----
	\$ 2394.50

REG. H. OZBURN,

*Secretary-Treasurer.*



## REPORT OF NOMINATIONS COMMITTEE

Your Committee proposes the following to serve as directors of the Society in 1953: G. F. Manson, B. N. Smallman, S. G. Smith, S. H. Short, A. W. A. Brown, J. H. H. Phillips and C. A. S. Smith (See Inside Front Cover for list of 1953 officers).

H. G. JAMES

W. G. P. GARLICK

H. W. GOBLE, *Chairman*.

## REPORT OF RESOLUTIONS COMMITTEE

- (1) Resolved that the Entomological Society of Ontario hereby express its appreciation to Dr. J. D. MacLachlan, President of the Ontario Agricultural College, for his cordial address of welcome and for the use of the Institution's facilities during the 89th Annual Meeting of the Society.
- (2) Resolved that the Secretary forward a letter of appreciation to Dr. K. W. Neatby for his delightful and informative address "Agricultural Research in Australia".
- (3) Resolved that our thanks be expressed to the Programme Committee for a well-balanced and interesting series of invitation and submitted papers.
- (4) Resolved that the cordial thanks of the Society be extended to the Local Committee for its excellent arrangements.
- (5) Resolved that the pleasure of the Society be expressed to Professor and Mrs. A. W. Baker for their Open House which has been a very enjoyable feature of our Guelph meetings for many years.
- (6) Resolved that the Society express its appreciation and gratitude to Librarian S. E. Dixon and Mrs. G. H. Unwin for the preparation and publication of the List of Publications in the Society Library.
- (7) Resolved that greetings and congratulations be forwarded to Past President Dr. John Dearnness on attaining his 100th birthday.
- (8) Resolved that a letter be forwarded to Mrs. Caesar and family expressing our sympathy in the passing of Professor Lawson Caesar.

The Committee requests that the actual phrasing of the last two resolutions be left to the Secretary-Treasurer who should consult with at least one of the older members of the Society.

A. W. A. BROWN

O. PECK

W. E. HEMING, *Chairman*.

MEMBERS AND GUESTS REGISTERED  
AT THE EIGHTY-NINTH ANNUAL MEETING,  
ENTOMOLOGICAL SOCIETY OF ONTARIO, OCTOBER 16 AND 17, 1952

Allan, W. C. .... Guelph  
Armand, J. E. .... Picton  
Baird, A. B. .... Ottawa  
Baird, R. B. .... Kingston  
Baker, A. W. .... Guelph  
Begg, J. A. .... Chatham  
Bond, E. J. .... London  
Boyce, H. R. .... Harrow  
Boyce, K. E. .... Chatham  
Brown, A. W. A. .... London  
Bucher, W. E. .... Kingston  
Burnett, T. .... Belleville  
Butler, W. E. .... London  
Carmody, H. C. .... Toronto  
Carpenter, W. S. .... London  
Cass, L. M. .... Ottawa  
Chefurka, W. .... London  
Chillcott, J. G. .... Ottawa  
Code, W. R. .... Windsor  
Coppel, H. C. .... Belleville  
Crawford, H. G. .... Ottawa  
Davies, D. M. .... Hamilton  
de Vos, A. .... Guelph  
Downe, A. E. .... Kingston  
Dustan, G. G. .... Vineland Station  
Finnegan, R. J. .... Toronto  
Fisher, J. C. .... Harrow  
Fisher, R. .... London  
Fletcher, Fred W. .... Midland, Mich.  
Garlick, W. G. .... Vineland Station  
George, J. A. .... Guelph  
Goble, H. W. .... Guelph  
Graham, A. R. .... Belleville  
Gray, D. E. .... Ottawa  
Gregory, F. W. .... Niagara Falls  
Hall, J. A. .... Simcoe  
Hartley, J. B. .... London  
Heming, W. E. .... Guelph  
Herron, John .... New Marshfield, Ohio  
Herne, D. C. .... St. Catharines  
Holland, G. P. .... Ottawa  
Hudson, F. J. .... London  
James, H. G. .... Belleville  
Judd, W. W. .... London  
Kirby, C. S. .... Toronto  
Laing, W. S. .... Toronto  
Lalonde, V. .... Chatham  
Lapp, W. R. .... Windsor  
Laughland, J. A. .... Guelph

Lochiavo, S. R. .... Ottawa  
MacDonald, G. .... Sault Ste. Marie  
MacLellan, C. R. .... Kingston  
MacLachlan, J. D. .... Guelph  
MacNay, C. G. .... Ottawa  
Manson, G. F. .... Chatham  
Martin, J. C. .... Belleville  
Maybee, G. E. .... Belleville  
Miller, C. D. F. .... Ottawa  
Miller, L. A. .... Chatham  
Miller, R. C. .... Vineland Station  
Monro, H. A. U. .... London  
Monteith, L. G. .... Belleville  
Moreland, C. R. .... Guelph  
Morgan, G. T. .... Kingston  
Morrison, G. E. .... Sault Ste. Marie  
McClanahan, R. M. .... London  
McIntyre, R. E. .... Toronto  
McKeen, D. C. .... Toronto  
McKercher, J. T. .... London  
Neatby, K. W. .... Ottawa  
O'Brien, R. D. .... London  
Ozburn, R. H. .... Guelph  
Patterson, D. .... Vineland Station  
Paxton, V. R. .... Toronto  
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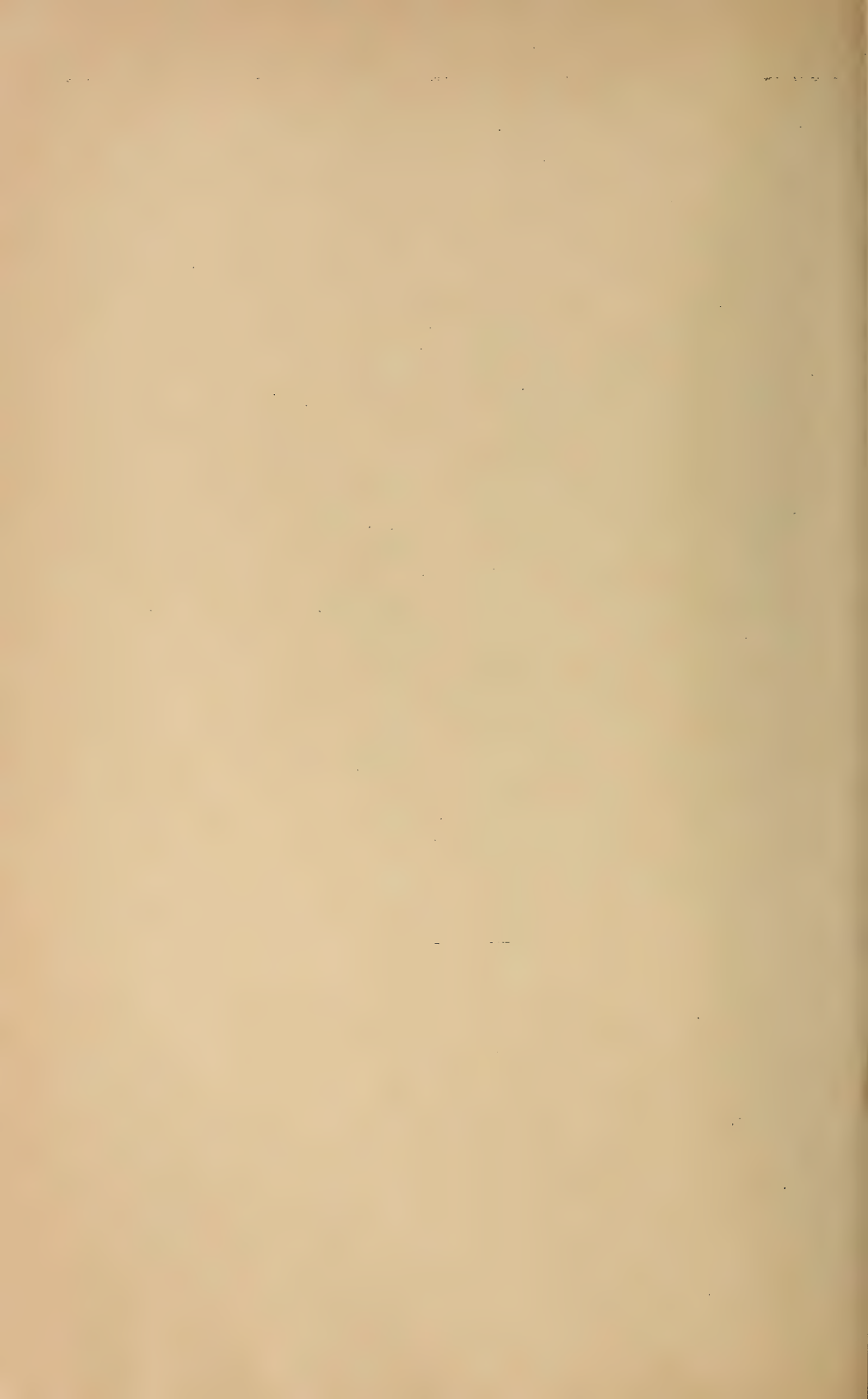
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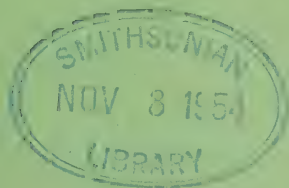
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## SYMPOSIUM

on

## RECENT LARGE-SCALE OPERATIONS IN INSECT CONTROL

During and since World War II large-scale insect control operations were not uncommon. The Programme Committee felt that discussions of some of these would be of interest and value to members of the Society and guests. Dr. Hubert Martin introduced the subject and the speakers and led the discussion. The following presented papers: E. J. HAMBLETON, Plant Pest Control Branch, U.S.D.A.; B. W. FLIEGER, Forest Protection Limited; H. E. GRAY, Division of Entomology, Ottawa; and A. W. A. BROWN, University of Western Ontario.

RECENT PROGRESS IN THE ORGANIZATION AND  
CO-OPERATION OF INTERNATIONAL LOCUST CONTROL

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Perhaps no other insects have attracted more attention or lend themselves to large-scale control operations as well as do the migratory locusts. Likewise, from an international point of view, no other insects constitute so great a potential danger to food production within the many countries inhabited by one or more species. The desert locust, *Schistocerca gregaria*, has plagued the Middle East, North and East Africa, and South Asia for centuries. A closely related species, *Schistocerca paranensis*, is active in South and Central America. Other migratory species are common in Africa, the Mediterranean area, and Asia.

In reviewing the organization and co-operation of international locust control, I will confine my remarks chiefly to the desert locust, because it is with this species that we in the United States are most concerned in our program of technical assistance in the Eastern Hemisphere.

From Biblical times to the present day the desert locust has menaced crops throughout the vast area over which it ranges. Literature on the locust problem published in about a dozen languages is voluminous. But only within recent years, after much painstaking research and field exploration, have entomologists voiced the opinion that locust plagues can be predicted fairly well and brought under control. Until World War I much speculation existed regarding the behavior of locusts, the mass movements of "hopper bands", and migrations of swarms. No one knew where they came from or where they went. As the knowledge of their life history and behavior was gradually brought together, much of the mystery of how plagues develop was cleared up.

Most important was the discovery that between plagues the desert locust reverts to a grass-hopper that leads a solitary existence. The phenomenon of phase transformation is believed to be related to population density. The relation between climatic factors and the development of the solitary and gregarious phases has been the basis of continued research ever since Uvarov and Faure shared this discovery in the early twenties. These two scientists were able to explain how locusts managed to exist for long periods between outbreaks.

Since recent strategy in locust control aimed at the prevention of outbreaks, it was necessary to find out where locust swarms originate and what causes them to swarm. Answers to these questions were eventually found for two locust species, and it was learned that there are many outbreak areas, some of which are not yet clearly defined. Much of the present-day locust re-



search consists in studying the outbreak areas and conditions that influence swarming of the desert locust, as it is not yet known with any certainty where recent plagues of this species have originated.

Solution to the locust problem will probably come only when man has removed such physical and political barriers that stand in his way. It seems from recent achievements that removal of these barriers may be the easiest way to prevent the formation of swarms in outbreak areas. Locusts breed, migrate, and cause damage almost continuously, every month of the year in one part or another of their wide geographical range. Locust depredations do not always recur annually, but come in cycles of several years. Countries faced with imminent danger at any particular period make frantic efforts to organize their defenses at considerable cost, but in years when locusts are of less importance, populations are permitted to build up again until they recur as plagues.

As more emphasis was placed on the locust problem over the years, it became apparent that the efforts of an individual country were not enough. Locusts were not respectors of national boundaries. Swarms of desert locusts migrated from country to country, flying thousands of miles. Control measures applied in any one country often saved the crops in a particular season, but it had little effect on the overall locust situation.

Such tremendous obstacles as mountain ranges, vast stretches of desert, and lack of transportation and communication facilities in thinly populated areas have deterred man's ability to cope with the locust. The same obstacles have likewise hampered the efforts of governments and entomologists to overcome what might be called indifference toward a problem that is truly international in all respects. The initial attempts to hold international conferences for discussion of the problem were none too successful. After increasingly serious outbreaks that developed into plagues of many years' duration, the attitude of peoples has changed as knowledge of locusts has increased and was made available to all concerned.

To the Government of Great Britain and her able scientists we owe major credit for the present-day concept and policy on most matters pertaining to locusts and their control in the Eastern Hemisphere. The work of the Anti-Locust Research Centre in London, under the direction of Dr. B. P. Uvarov, has been the focal point from which modern large-scale prevention and control activities have developed. This independent institution assembles and analyzes information on locusts for nearly the whole world. From this information forecasts are despatched to all interested governments. The Centre also advises on research and control of locusts.

Largely through the inspiration emanating from the Research Centre, locust experts from Britain, France, Belgium, India, Egypt, and South Africa undertook systematic explorations in the field. A new spirit of co-operation developed as these and other scientists began holding annual conferences to exchange information and plan programs in research and control. Today almost every country affected by locusts has its experts and locust-control organization.

International conferences on locust control are now common. This bringing of nations together to exchange scientific data and reach agreements on principles of locust control has been stimulated by a greater demand for agricultural commodities in the underdeveloped areas. Close co-operation between nations and the sharing of knowledge with each other through friendly personal contacts are as necessary to success in the solution of the locust problem as they are in solving any other international problem, be it political or entomological. Our meagre experience in providing assistance to nations affected by the desert locust during the last three years has demonstrated that the willingness to work together toward a common cause can be achieved in spite of certain handicaps. We are glad to have had an opportunity to help alleviate the problems underlying unrest in offering some assurance that food crops could be saved by prompt action in controlling locusts. The reluctance by people to plant in areas known to be subject to locust damage seriously affects agricultural production and stability. Thus in meeting the challenge the United States Government helped to renew confidence and restore faith of the people of Iran at a period when they were in need of outside assistance.

Our participation in locust control in the Middle East stems from a request for assistance made by the Government of Iran in the spring of 1951, when that country had one of its worst invasions in eighty years. Similar requests were made to the United Kingdom and Russia. It was not a matter of arousing interest in what might best serve Iran under the Point Four program. It was a question of material aid at a critical period. The Iranian Government requested insecticides and specified benzene hexachloride, a product with which they were familiar and which was the principal ingredient in the poison baits they had been using for controlling the desert locust. The supply of BHC requested by the Iranian Government was not readily available in the United States at the time. The insecticide aldrin was available and could be prepared for air shipment immediately. Although the Iranian entomologists had had no experience with aldrin, they were eager to accept it as a substitute for BHC when informed that the United States would also be willing to send eight small spray planes with pilots and an entomologist to direct and co-ordinate the work. Within three weeks from the time of the request, fourth-instar hoppers were being attacked from the air.

In the course of 3 months, about 53,000 acres were sprayed in 18 widely separated localities in southern Iran. The areas selected for spraying were those in which the immature locusts were rapidly approaching the adult stage, when they were likely to migrate northward into the better agricultural areas of the country. Aldrin proved highly effective when applied at the rate of 2 to 3 ounces of technical material in 1 gallon of Diesel oil per acre. Fields of wheat, barley, and other crops, as well as date palms and pasture lands were sprayed where concentrations of locusts were heavy. From 95 per cent to complete kill resulted in 24 to 48 hours.

The remarkable feature of this emergency program, carried out as part of the Point Four program of technical co-operation, is the rapidity with which the project was outlined and the machinery set into motion. It demonstrated that nations can work together to meet emergency situations. At this point I wish to call attention to the help that the Point Four mobile air unit received from Iranian and British officials. Much credit for the project's success was due to officials of the Anglo-Iranian Oil Company at Abadan. They contributed fuel for the planes, Diesel oil diluent for the insecticide, and transportation of both these items and the insecticide to the infested areas. Two English entomologists joined the combat forces in helping to locate the most strategic areas for control operations. English aircraft also played an important part in the campaign by flying in several tons of BHC for use in poison baits. They also transported personnel, equipment, and supplies to areas of field operations.

The Iranian anti-locust program was well organized in 1951. The area of infestation was carefully patrolled for observations on locust movement and egg laying. From 12 to 15 mobile units, for which the Iranian army supplied trucks, operated in patrol work and transportation of personnel and poison-bait. The local organization accomplished excellent results and co-operated effectively with our airplane-spraying force. This emergency aid on locust control to Iran clearly indicated how modern techniques can be applied successfully in programs of technical co-operation with other governments. It also proved that aldrin was effective against the desert locust and that this species could be controlled by spraying with aircraft, a method hitherto untried in that part of the Middle East. It also increased the confidence of locust-control officials in other countries. During the initial operation in Iran observers from Pakistan and India were on hand, and it was not long before official requests from these countries resulted in similar assistance and control demonstrations. A total of 16,600 acres were sprayed in Pakistan and 5,300 in India. In Pakistan it was discovered that oil diluents were not required for the 60-percent Aldrin concentrate but that water served the purpose just as well at considerably less cost.

This direct aid to Iran, Pakistan, and India in the spring and summer of 1951 stimulated interest and threw a new light on the locust problem throughout the infested areas. Several meetings were held in Washington to consider what further measures might be taken under the technical-assistance programs. Officials of the Department of Agriculture and the former Technical Co-operation Administration of the State Department, which then administered the Point

Four program, agreed to set up a long-term project of technical assistance to countries in their struggle to combat locusts and preserve their food crops. The United States was prepared to give this kind of aid at once. We already knew enough about killing locusts to suggest a practical program that would appeal to the afflicted nations. Our own Congress favored an action program and did not expect Point Four funds to be expended exclusively, or to any great extent, on research; yet we realized that research in all phases of locust control should continue.

In September 1951 plans were formulated for a regional locust-control program to be operated by the Technical Co-operation Administration in co-operation with the U.S. Department of Agriculture. The Food and Agriculture Organization of the United Nations, realizing the need for stronger co-ordinated organization between countries, called a conference in October. Delegates from 13 countries met in Rome. Plans of national campaigns submitted by various countries were reviewed, and recommendations were made for means of providing supplies to countries in need of them. The FAO council, approving these recommendations, established an Advisory Committee on Desert Locust Control. On this Committee are experts from Egypt, France, India, Iran, Pakistan, United Kingdom, and the United States. It has been meeting once or twice each year to discuss locust-control strategy, appraise the locust situation, indicate priority of infested areas, and advise the FAO on policy.

FAO, prior to 1951, had made some progress toward international co-ordination of locust control in both the Middle East and Central America, but was unable to contribute financially or in any other material way to the existing control programs. The advisory Committee held its first meeting in Rome in March 1952. By that time a regional project had been set up and approved by TCA in the Department of State. It provided for small spray planes and insecticides to be used under the direction of a United States entomologist, who is also the United States representative to the FAO Advisory Committee. The technical aid would be administered under bilateral Point Four agreements with countries in the desert locust area.

With FAO's new role in this work and direct aid made available by the United States, every means was taken to arouse the interest of these countries in what might be done under technical-assistance programs. It was believed that FAO could be most effective in what might be called the political organization of the region for the acceptance of a campaign. Since FAO had been operating other programs in many of the countries affected by locusts, it was believed that its technicians and officers could facilitate entry and bring about co-operative action more promptly than could any single government.

At the Rome meeting in March, FAO offered to provide \$500,000 under their Expanded Technical Assistance Program during the 1952-53 campaigns. This amount was allocated for trucks, sprayers, dusters, airplanes, and insecticides under bilateral agreements with member nations in the threatened areas. Some of this equipment and supplies were air-lifted to save time in meeting demands. Reserves of supplies were also placed at two geographical points where they could be readily dispensed to the areas in need. O. B. Lean has been in charge of FAO's contribution to locust control. Mr. Lean was chief locust officer of the Middle East Anti-Locust Unit during the war years, and he headed the East African Desert Locust Control Organization when he was called to his post in FAO.

The work of the Desert Locust Survey and Control Organizations of the East African Commission is well known in all locust-infested areas. Staffed with approximately 150 officers and administrative personnel and operating in 11 countries, these two organizations have accumulated vast information and experience on locusts and their control. Forecasts emanating from the Anti-Locust Research Centre in London are based largely on reports from officers of the two organizations headquartered at Nairobi. United Kingdom locust organizations are sympathetic to FAO's role in locust control and consider it of value in planning toward more permanent organization. British experience has been invaluable to FAO and all afflicted countries.

In 1952, as in previous years, the United Kingdom bore the brunt of all locust control in East Africa and the Arabian peninsula. But swarms of locusts escaped and moved northward, across the Red Sea through the Arabian peninsula. By mid-February they had fanned out into the



Kuwait Province, southern Iraq, Iran, and Jordan. The rapid expansion of the plague was recognized as being due to a failure to conduct adequate control operations the previous season. All attention was turned toward the Middle East. Locust breeding occurred largely in the desert, and if uncontrolled, new swarms would penetrate agricultural areas and could cause extensive damage. The plague would consequently spread to other areas and become of greater importance in Pakistan and India.

In the spring and summer months of 1952 we witnessed international co-operation in action as never before. Other countries came to the immediate assistance of those most severely attacked. There was free exchange of essential supplies between threatened countries.

In northern Arabia, the British Control Organization was assisted financially by the Sudan and Kuwait. Teams from Egypt, Iraq, Syria, and Jordan also assisted in the area. In Jordan, the local government waged a successful campaign against a severe infestation. FAO provided some material aid, and the Arab Legion proved itself an efficient control force. Early in April two American Point Four spray planes were despatched to southern Iraq, where they operated in 10 communities in the desert south of Basra. Locusts were controlled on about 100,000 acres, of which 12,655 were treated with insecticides by the two planes during a 7-week campaign. Aerial applications of insecticides were demonstrated under various conditions that were difficult for ground control work.

The infestation in Iran, where egg-laying was reported to have covered over 1,500,000 acres, was unusually heavy. Nevertheless, Iran's locust-control organization was fully mobilized, and its Army took an active part in the heavy transport. Preparations for the Iranian campaign offered one of the finest examples of international co-operation in pest control. India, Italy, Pakistan, Russia, Turkey, and the United States all co-operated by supplying insecticides, bran, spray equipment, trucks, jeeps, and planes. FAO provided 18 vehicles and one ton of insecticide and shipped 13 tons of insecticides by air from India. Aerial demonstrations in Iran, like those in Iraq, were conducted where locust infestations were most serious and where planes could be used to advantage over ground control operations.

As the season progressed the campaign extended into Pakistan and later into India. By the end of May four U. S. planes and pilots were assigned to Pakistan, two based at Panjguar and two at Sakrand on expected locust flyways, to operate on incoming swarms. Infestations were light and scattered, but by October 1 became more intense. By October 28, 616 loads of insecticide had been sprayed on 30,640 acres. Three planes sent to Jodhpur, India, in early July operated in five localities. A total of 21,955 acres treated in India gave protection to an estimated 250,000 acres of crop and range land.

The U. S. Regional Locust Control unit has supplemented the efforts of various national and international agencies, including FAO, in the fight against locusts in countries of Asia, the Middle East, and Africa. Previously control efforts were confined almost exclusively to ground operations consisting in applying poison baits by hand. Control operations of this kind, conducted largely on an individual country basis, proved only partially effective because of the vast and inaccessible areas inhabited by locusts and the difficulties of transportation. The Point Four regional operations have added aerial reconnaissance and spraying, which not only have increased the effectiveness of the ground operations but have added a distinct control measure which has met the approval of governments wherever it has been demonstrated. In addition, they have served as a basis for the important function of co-ordinating the efforts of the various nations within whose borders locusts must be combatted, and thereby contributing to progress in international co-operation by these nations.

The Regional Locust Control Program is an outgrowth of the successful operation undertaken by the Technical Co-operation Administration for 1951 programs in Iran, Pakistan, and India. It was enlarged in 1952 to provide for regional operations at the request of co-operating nations. The operations are co-ordinated under a field office located at Beirut, Lebanon, which

is supervised by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture under authority delegated by the Foreign Operations Administration. In the fiscal year 1952, nine Piper Cub airplanes, equipped with the necessary instruments, spraying gear, and spare parts were purchased and placed at the disposal of the program director, who is in charge of the Beirut headquarters. In addition to the program director, William B. Mabey, who helped control western grasshopper outbreaks for 18 years before accepting the foreign post in 1951, there is a staff of four entomologists and one administrative assistant. The planes are operated by nine pilots and mechanics provided for under a commercial contract. The planes usually operate in units of three, with an entomologist supervisor over each unit. The program director is authorized to dispatch them to any country with whom bilateral agreements to meet locust outbreaks have been signed and to adjust the program to best fit the needs.

Briefly, the objectives of this program are (1) to assist the countries of South Asia, the Middle East, and Africa in the control of the desert locust through the demonstration of aerial spraying techniques and reconnaissance as a supplement to other control measures used against the locust and other insects; (2) to assist in the training of native pilots and mechanics to provide for the continuation of aerial spraying, and in the training of local entomologists in field survey and control methods; (3) to give guidance and assistance in the co-ordination and execution of aerial and ground control activities; and (4) to promote international co-operation by working with technicians and authorities of individual nations and other agencies concerned with the control of the locust.

To date, the regional program has served Iran, Iraq, Pakistan, India, Jordan, Ethiopia, Lebanon, Saudi Arabia, and Libya. Spray demonstrations have been conducted in six of these countries. Agreements with countries are for one year, but may be extended or amended according to the needs and availability of funds.

The total cost of this program to the United States has been less than \$400,000 annually. This is a fraction of the cost sustained by all the participating countries which is estimated to be approximately \$12 million annually. The U. S. Regional Locust Control Program is not in any sense a give-away program. Participation of host countries consists largely in providing (1) ground support for aerial spraying, gas and oil for the aircraft, and assistance in their maintenance; (2) transportation of insecticides, fuel, water, and other supplies; (3) lodging and meals for U. S. personnel when not otherwise available; (4) trucks, jeeps, and hundreds of laborers; (5) insecticides and bran for baiting in ground control; (6) technicians to supervise their own operations and co-operate with the regional control personnel.

The objectives of the Regional Locust Control Program have received popular and governmental acclaim in the Middle East, South Asia, and Africa. The control of locusts will enable the people of the countries to increase plantings and employ improved methods of production without fear of heavy losses caused by the insect, which has been a menace to the crops of the areas from time immemorial. It is further evident that there is available in the western world the technical knowledge, equipment, and materials necessary to assist in securing economic control of the locust. The program is credited with saving many thousands of acres of farm crops and pastures. It has also stimulated nations to increase their own budgets and control activities, and to work together to combat locusts early in their breeding areas, without detracting in any manner from a country's responsibility for locust control within its own borders.

Through such progress as here outlined, together with the continued support of all locust control organizations, and particularly of the Food and Agricultural Organization of the United Nations in co-ordinating control activities, it is believed that the locust problems of the Middle East, South Asia, and Africa can be greatly diminished, and that the people of those areas will be properly organized and prepared to cope with the problem more effectively both nationally and internationally.

FOREST PROTECTION FROM THE SPRUCE BUDWORM  
IN NEW BRUNSWICK

B. W. FLIEGER

*Forest Protection Limited*

We need to remember from time to time that Eastern Canada is still a forest country, however many other wonderful attributes it may have—a country for the most part of coniferous forests. From whatever vantage point we view it, we never see more than an infinitesimal part of the whole forest and therefore, we need to remember, too, that in extent and character it is one of the greatest sources of valuable wood material in the world.

Many of us have still to find out through experience that this forest is a wild and natural jungle and not, in any respect, tame or artificial in the sense that it has been grown and tended by man.

Perhaps we should forget to some extent a feature of the forest which so strongly impresses us as to mask from our eyes much of what goes on within this natural dynamic complex. I refer to its stability—stability in the sense that the forest has persisted from a point in time far back in antiquity down to the present. To nature lovers, sportsmen, woodsmen, entomologists, and others alike, the forest has given this impression of stability—all too often, and to too many it has been the stability of the full-rigged ship in the wine bottle—so little does it seem to change in our eyes from day to day.

In order to get close to the life of the forest we need to cultivate an alertness of mind toward the time dimension. This is so necessary in order to describe change and especially so is it in the study of forests in order to appreciate the grand manner in which nature rotates its crops of trees.

The number of tree species, native to the forests of Eastern Canada, is unimpressive. Not so, however, are the combined abilities of these trees which are sufficient to keep the land in growing forest under natural conditions.

At the very top of this list we must give place to the often discredited balsam fir. This species of tree can tolerate a wide variety of growing conditions. It can succeed itself for generations in certain situations and by infiltration, form a part of most forest stands at some time or other. It is a tree which matures early and is short-lived. Balsam fir is prolific in the production of seed. It is well known for its ability to become dominant in the forest in the wake of other species though this may require more than one generation to accomplish. Fire seems to be the only immediate deterrent to regeneration of balsam fir. There is not much doubt but that it is the favourite host of the Spruce Budworm. It has become important to man—chiefly as raw material for pulp and paper.

From time to time great populations and volumes of balsam fir are to be found in the forests of this region and at all times a considerable amount. At any time there is the possibility that an outbreak of spruce budworm will occur in a locality where the forest condition is able to support it. In those times when there is a preponderance of balsam fir throughout the forest region such an epidemic may be extensive and progressive. The present epidemic is a case in point (1935—). But there have been others in the past, (1910-1921), (1805-1815). It is a fact that the position and amount of balsam fir in the forest region has varied greatly from time to time for ages past, and that the spruce budworm has been closely associated with the changes.

Apart from the array of plants which make up the forest scene, and the many combinations of plants that occur, one is impressed by the apparent long history of wild fire in the forest. It seems strange, too, that much of the forest which man has found most attractive and in which he has carried out operations for wood has been of the kind that has grown after fire—the famous pineries of the early settlement days and the very common even-aged spruce-jackpine pulpwood forests to cite only two examples.



There is not much doubt that all of the very large forest fires in the history of the entire region have been made possible through the action of forest insects. Extensive damage from this source is the only way in which a fuel pile can accumulate on the ground at one time over extensive areas. Lightning has ignited such fuel piles in the days before matches, and is still doing so.

Nor is there much doubt but that investigation will prove the existence of a highly significant relationship between balsam fir, spruce budworm and forest fire. It will indicate also that in nature this relationship has produced in large measure the gross pattern of change in much of our forest land. Perhaps it may show that there is a connection between these changes and the sustained ability of land to produce forests.

The signs of wholesale alternation of forests abound throughout the boreal and neighboring forest regions. The two principal faces of this rotation, namely forests after fire and forests susceptible to spruce budworm attack and the gradations in between are in the land for all to see.

Because the entire coniferous portion of the forest region is never composed of just one of these two main kinds of forest so it is impossible for the spruce budworm in epidemic form to spread into all of the forest and feed to the point where in all situations trees are killed. However, areas of forest which have been severely mauled by the budworm may be revisited by the same insect as soon as stocks of balsam fir have grown back in sufficient amount to support heavy infestation. This occurs when fire has been kept out. We have this very situation in New Brunswick today where we find budworm working through an area in which the same insect caused severe damage thirty-five years ago. So much for theories about changes in the forest.

#### *THE SPRUCE BUDWORM IN A NEW ROLE.*

The spruce budworm is a forest insect noteworthy, I think, for the immense tonnage of needles which it has been able to consume during that long interval of time in which it has enjoyed complete anonymity. Lately in this period its depredations in the forest became a curiosity—this coincided with the very early settlement years, in which balsam fir and spruce stands might be destroyed and not be missed. Still more lately the budworm became a nuisance and an aggravation in the years when the timber trade was not unlike the fur trade. Of course there came the day when it became an object for study—as soon as there was an entomologist to find it on a spruce tree and label it for posterity. Finally, and very recently, and just in part of the forest region, has the full stature of the insect manifested itself. Now for the first time it looms as man's competitor for the same wood pile.

This defoliating insect which prefers the succulent new needles of balsam fir and spruce is, as far as we know, the most destructive of our forest insects. It is native to the region and so are its natural controls. In low population levels no damage to trees results. Present in endemic numbers in the forest at all times and considered by some entomologists to be epidemic somewhere in the forest region most of the time it can, at its peak of fury and voracity, kill all balsam fir and spruce within reach. Trees of all ages may be killed, not only the overmature classes. It leaves in its wake a condition of high fire risk.

Why the insect breaks its bonds from time to time is not completely understood. It is known that some forest conditions are highly susceptible to infestation and that certain weather cycles of long duration seem favorable to the generation of heavy populations.

There is no control known in nature to stop an epidemic. Entomologists know well its power to destroy and have for some time been suggesting possible methods of control. I shall never cease to wonder at the collective power of billions upon billions of budworm larvae and how in the space of a few years, working about one month a year, this power can change the forest over thousands of square miles—something man could not do in ten times the time working year round.

*THE FOREST HAS BECOME VERY IMPORTANT.*

One hundred and fifty years ago the forest was being exploited for little more than timber squares of pine and birch and for timbers used in the wooden shipbuilding trade. About this time the budworm ravaged the forests of New England and adjacent Canada.

Introduction of the sawmill brought about an increased exploitation of the forest for sawlogs. The lumber business after one hundred years, still flourishes in parts of the forest region and up until the nineteen twenties, monopolized the forest scene. In all this time there was more forest than the industry was able to exploit. As far as I know this period was free of spruce budworm epidemics comparable in extent with the present one except in the years of World War I, when there occurred a widespread infestation of the insect with resulting heavy damage. The effect of this damage to forest upon the lumber trade was minimized by the great translocation of business which took place soon after the insect epidemic subsided. The newsprint part of the U. S. pulp and paper industry moved into Eastern Canada and began to grow into the giant which it now is. Many forest holdings and old lumber firms merged into this new business. Some famous Canadian lumber companies became paper companies. In these days there were more timber cruisers in the forest than budworm and widespread insect damage was far from the minds of men. There was a great scramble for forest limits to provide the raw material for the new pulp and paper mills.

Subsequently we heard for the first time in this region of plans for the orderly development of wood cutting and for the protection of the forest. Provincial Governments enacted legislation to control the use of Crown forests—most of the forest is still held in the right of the Crown by the Provinces. Forest industries since that time have spent large sums of money in making their forest holdings more accessible and in their protection of the forest from fire as well as on plans for the continuous use of the forest.

Of course these events took place in New Brunswick as well as in Ontario and Quebec.

*FOREST MANAGEMENT IN A NEW ROLE.*

New Brunswickers, it is said, depend more on the forest for a living than do Canadians in any other province. In spite of its relatively small size, New Brunswick contains over 20,000 square miles of forest, and a very sizeable portion of the country's forest industry. For some time now there has been no surplus forest land: i.e. all forest land is occupied.

When the budworm began the latest trek across Eastern Canada, its progress was watched in New Brunswick with crossed fingers. By 1950, any hope that the Province would be bypassed by the epidemic was given up. By 1951, there was general concern over the condition of part of the forest. New Brunswick International Paper Company was especially concerned over the fate of a valuable tract of limit which had been infested heavily since 1949. The Paper Company and the Province decided to do something to save this forest.

And so it came about that a new step in the direction of forest protection was taken. The same kind of step that had been taken long before to fight wild fire in the forest and although this fight has seesawed back and forth, it has never been given up.

Before there can be waste or loss, there must be values, and after values comes protection of values—this is so in the forest as well as outside. When wood values become high enough, toleration of danger to these values on the part of those interested, gives way to positive action.

It is natural that large scale forest spraying operations "brewed up" in northern New Brunswick, because all of the necessary ingredients are there. Let me list them for you:

- (a) Forest land all occupied
- (b) Most available raw material in forest susceptible to budworm damage
- (c) Spruce budworm in epidemic numbers firmly entrenched for some time

- (d) No sign of abatement in the epidemic
- (e) Industrial plants fixed in location
- (f) Close to 60% Provincial income from forest.

When forest entomologists were asked about control measures they could suggest only spraying with insecticide and were not putting any money on spraying because it had not yet proved itself able to control spruce budworm.

#### *SOME HIGHLIGHTS OF FOREST SPRAYING — NEW BRUNSWICK 1952*

It was in September 1951 that the decision was taken to carry out forest spraying in the Upsalquitch region of New Brunswick in 1952. This left about six months to get ready. Fortunately there was considerable experience in this work to draw upon. There had been no extensive forest spraying operation in Canada since 1946. During the years 1945 and 1946 large scale forest spraying experiments had been conducted in Northern Ontario. Experience gained in this work helped greatly in the design of forest spraying techniques employed in the U.S. Pacific Northwestern States, where since 1919 extensive areas have been sprayed annually to combat the spruce budworm, which has been epidemic in the Douglas Fir region.

The Paper Company undertook to plan and execute the project. Science Service, Department of Agriculture, was responsible for all biological control and co-operated closely throughout the planning stage of the project. The application of insecticide was carried out by contract and payment for this service was by acres sprayed to the satisfaction of the customer. This required an intensive assessment of spray deposit and in doing so a very good picture of the distribution of insecticide was obtained.

The following list is made up of items, which as far as is known are original, and are peculiar to the New Brunswick 1952 spray project.

- (1) A flying base was constructed in November, December and January in winter weather. It was brought to operational condition in June and used as the sole base of operations. This was located 65 miles from railhead.
- (2) A fully formulated insecticide was selected consisting of technical grade DDT in the amount of one pound to one U. S. gallon of formulation, the only other ingredient being a solvent oil. The whole shipment, almost 3800 drums, was taken, as delivered at railhead, by truck to the base where they were stored outside through a fairly severe winter.
- (3) A method of spray assessment was developed. This employed paper coated with oil-soluble dye upon which spray left its speckled trail. Since the paper retained its story and was sensitive to spray, wet or dry, over a considerable period of time, it could be used in many situations in which glass or metal plate equipment was of no use. The design of assessment of spray was completely changed by this discovery.
- (4) Single-engine aircraft operated in pairs as a regular procedure. This was decided upon for two very different reasons: a. In the event a plane went down while spraying, it was thought that search and rescue operations would reduce to rescue because the location of the downed plane would be known; b. When there was a strong chance that the project would not be completed due to bad weather, it was easier to keep the sprayed area toward the perimeter, continuous rather than spotty by reducing the number of spraying units. Spray assessment information indicated that a better distribution of spray was obtained in this manner but this was not the initial reason for the adoption of flying in pairs.

Perhaps the highlight of the operation was the smooth working of the aircraft loading-out plant. Though original in design, similar systems have been used in Oregon.

The insistence on the part of entomologists that care be taken to have the best possible application of insecticide of the standard theoretical dosage of one pound DDT per acre, indicated their feeling that only a very high degree of control would justify the effort.



The project was carried out more or less according to plan though bedevilled by the vagaries of the weather. Spraying began June 14th with the larvae of the insect, on the average, well developed and with serious inroads already made on the new foliage. It was completed by June 29th, at which time the stocks of insecticide were practically exhausted and pupation of the insect was imminent. Twenty aircraft in this period made about 1600 sorties and carried about 200,000 gallons of insecticide, which was put out over about 200,000 acres of forest. The operation, except for minor elasticities, was rigid in plan.

Results attributable to spraying were, according to the entomologists, little short of amazing. The insect population which before spraying was very heavy was almost wiped out. The kill was clocked in two systems of sampling, each of which corroborated the other. Strangely enough there seemed to be little correlation between amounts of insecticide deposited and kill. It is noteworthy to find this operational experience corroborated by research carried out at Kenora, Ontario, in the same year. The heavy kill was credited in part to saturation-spraying. Trees sprayed early in the programme showed most benefit in new foliage saved. All trees showed some benefit.

Spirits were high at this point, but not for long. In July and August a gigantic migration of moths took place. This was to spread the insect into thousands of miles of new territory. The sprayed area was engulfed. After egg-laying, it was found that the population inside the sprayed area was still not more than one third of that outside, but heavy enough, especially when entomologists estimated the density sufficient to clean off the 1953 foliage, and perhaps cause some backfeeding.

#### *PROGRAMME GAINS MOMENTUM — 1953*

The reinfestation of the sprayed area, though disappointing, did not obscure the excellent results of spraying. The insect could be killed. Operations could be expanded if necessary. Generally it was felt that the worst possible reinfestation after spraying had been experienced.

Interest in the project was widespread. Active feeding continued in neighboring forest areas. As a result of 1952 experience, a demand grew for a continuation of the treatment on a much larger scale in 1953.

In September 1952, the Bathurst Power and Paper Company, the Fraser Companies Limited, and the Irving Pulp and Paper Company joined with the Province of New Brunswick and the New Brunswick International Paper Company in an undertaking to spray 1,000,000 acres of forest in 1953. Together they formed a new company—Forest Protection Limited—for the express purpose of planning, co-ordinating and conducting spraying operations in New Brunswick. About this time the Government of Canada decided to assist the Province of New Brunswick in its campaign to help the forest.

It was urgent at this time of the year to secure additional bases from which to operate the large fleet of aircraft which would be required. Five airfields were located, surveyed and built. These fields were designed especially for the operation and consisted of two runways so that an uninterrupted flight pattern could be maintained during spraying periods. The detailed plan of operation which developed for the 1953 operation, in addition to being much larger than that for 1952, was quite different in that it was kept as elastic as possible.

For most purposes the work unit became the gallon instead of the acre. Allowance was made in the planning for any advantages that might accrue through improvements in the spraying technique, especially with regard to stretching or extending the coverage of insecticide. In this way the final plan made it possible to reach into an additional area of infested forest if the project operators found themselves in a position to do so. One million, one hundred thousand gallons of insecticide were stocked ready for use in the spring of 1953. The sprayer fleet was increased from 20 to 77. This strength was decided upon because of the avowed intention to push spraying forward to the earliest possible starting date in order that new foliage might be saved, thereby increasing the total favourable spraying period and the available work for each aircraft.

Prior to operational spraying, tests were conducted in the use of two sprayer aircraft flying as a team in tandem. Each pair was considered a spraying unit. The separation distance between the planes of the pair was fixed as a result of these tests. It was decided that a lateral separation distance of 250 feet gave satisfactory results, and this was followed for the entire operation. This method without changing the single plane output resulted in an application of a much lighter dosage of insecticide, in fact half that of 1952 or one half-gallon per acre. More important perhaps was the increased ability—twice that of 1952—to cover forest area. There are other reasons which make it desirable to fly planes in pairs and although the carrying away of insecticide from the airfields is slowed down slightly in this system, all other features of this technique are compatible and seem to be on the credit side.

The net result of spraying in this fashion was that 1,800,000 acres, 400,000 of which were given a second application (seven to ten days later), were treated instead of the minimum area.

Approximately 20,000 drums of insecticide were used. About 8,000 aircraft sorties were flown. The area covered was about one and one third times the size of Prince Edward Island.

Spraying was carried out over a period of 35 days, some of which were unproductive. The project was carried through to completion at all airfields, and practically all the stocks of insecticide were exhausted.

Aside from the regular programme of spraying, Forest Protection Limited, in co-operation with Science Service, Department of Agriculture, undertook to conduct field trials with insecticide formulations. These were on a fairly large scale and were conducted in a forest area containing a heavy budworm population. The results of this work will be useful in planning for the future.

The 1952 operation was completed at a very high unit cost. The 1953 operation, because of the greatly increased size, the methods employed, as well as a drop in the price of DDT, succeeded in cutting this unit cost in two. Costs were all on a pay as you go basis. It is possible, using the 1953 method, to apply insecticide again in the same areas, if it is required, at a unit cost much lower than that of 1953.

The kill produced was not as spectacular as that of the year before, and was perhaps more highly variable over the entire area. The saving of new foliage was also highly variable and the results were a bit clouded in certain places because of the occurrence of late frosts which killed buds and new foliage. After spraying had concluded at the end of June, surveys were made to assess results.

An intensive egg mass survey showed that, in general, the population of budworm in the areas sprayed thus far, had been lowered to the point where the potential larval population in 1954 can destroy only a portion of the 1954 foliage. This is the situation in areas sprayed in two consecutive years, twice in the current year and once only in the current year.

Prior to the 1952 spraying the thinking in regard to control was confined to the idea of killing the insect population over a limited forest area. It was stated at the time that the contemplated spraying was not directed against the entire budworm epidemic, but only a small part of it and in all probability would exert no effect on the course of the epidemic itself.

The attitude toward control and the emphasis in the spraying itself has altered somewhat since. The experience of the last two years has brought to light some points which are elaborated below:

- (a) Where spraying is carried on in an area of forest which itself is surrounded by active areas of infestation there is no known way of estimating in advance the occurrence or extent of reinfestation. This is in fact, spraying with the door open!
- (b) Reinfestation of sprayed areas does occur both from within and from without. After a good job of spraying very little is from within in the same year. Sometimes a sprayed area may be engulfed by reinfestation from without. This seems to depend to a great extent on weather during the moth stage.

- (c) Regardless of the motives built into a plan of forest spraying, and in spite of an up-to-the-minute knowledge concerning development of insects and foliage, the weather keeps a tight control over the actual spraying. Very often it is impossible to carry out operations at the most desirable times.
- (d) Provided the necessary bases are available for aircraft, and provided the necessity arises, it is possible to conduct spraying operations over larger areas in one season than have been attempted thus far.
- (e) In forest which is heavily infested it is difficult to confine spraying operations to bits and pieces of a general area which are of slightly older infestation. Apart from the difficulty it is questionable whether it should even be attempted without full consideration being given to the likelihood of complete reinfestation.
- (f) There is no apparent strong correlation between the amount of insecticide deposited and the nature of the kill. Good results seem to go hand in hand with complete distribution of insecticide.
- (g) There is a decided improvement in the condition of the trees after spraying. Where the insect population is reduced to the point where some of the current year's foliage is saved, this improvement carries further into the following year.
- (h) It is possible after successive applications of insecticide one year apart for trees to acquire much of their original vigor by the opportunity afforded them to build back a healthy crown of new foliage.

These points and others have had a significant effect upon the thinking of those engaged in spraying operations in New Brunswick, so much so that in the past year an attempt was made to acquire a technique which would prove faster in operation, cheaper, perhaps not quite so effective as saturation spraying, but a powerful deterrent to the budworm. Such a technique might be used whenever it becomes necessary to remove feeding pressure from trees.

Some degree of success was experienced in this direction in 1953 which is encouraging to entomologists as well as foresters. There is some opinion now in favor of repeated spraying of the same area whenever this is judged to be necessary, instead of reliance upon a single saturation application which might fall short of producing the desired effect. Thus reinfestation of an area may to some extent be bypassed and trees may be kept alive.

This is quite a long jump from the opinion held in the beginning of the spraying operations as to the ability of insecticide to kill a population. The concept of spraying a forest through an epidemic in such a way as to keep trees alive is perhaps not original but it is certainly original in the case of the New Brunswick experience. It leads the forester to believe that equipped with not too expensive a tool and provided the fringe effects are not too drastic, a limited area of valuable forest might be treated over a period of time as long as ten years (not every year). This might mean not more than three or at the outside four applications of insecticide.

In forest spraying operations in New Brunswick we are not concerned as much now as formerly with the dosage-mortality relation—instead we are trying to deliver some insecticide to every spot of the forest area in the spraying plan and are attempting to improve methods, reduce the hazards which are inherent in this type of work and place the entire programme in a position in which further treatments might be favourably considered.

As far as operations have progressed, the results have been most encouraging. The forest spraying programme in Northern New Brunswick is considered good forest management, in that a forest situation is receiving the attention which it deserves and resulting actions are the best that can be devised at the time.

While the current epidemic has been moving East into New Brunswick and Gaspé, a seemingly less positive (salvage) approach to forest management has failed to keep pace with the insect. Salvage and presalvage woods operations—how far away from this category have been the ord-



January wood cutting operations so far? It is known from experience, some of it very recent, that there is no comfort in the thought that insect damage can be balanced by cuttings after the damage. The truth is that forest industries neither now, nor in the future, will be able to salvage more than a small portion of trees killed in widespread insect epidemics throughout the balsam fir-spruce forests.

Entomologists have said that there would be no severe outbreaks of spruce budworm, if balsam fir could be kept from maturing in large numbers. This, by itself, is a high-sounding, safe statement. Without a method to produce the result it becomes, in addition, completely unrealistic. How does one go about keeping balsam fir out of the forest and if that is not possible, how does one use balsam fir before it matures?

#### *FOREST SPRAYING IN NEW BRUNSWICK IN ITS THIRD YEAR*

Forest Protection Limited is planning to continue the programme of forest spraying over an additional one million acres of infested forest in 1954. This decision is taken after consideration of the nature of the infestation and the results of work already completed, particularly that in 1953.

In this type of forest protection work we are living with an insect epidemic and are finding out how powerful it is. We are also finding out, by watching the trees as well as the insects, how important is the relief from only part of the feeding pressure to the individual tree. It is when attention is directed toward the host forest, particularly its reactions to insect feeding and to forest spraying, that there is the opportunity to decide what can be done in an emergency to save limited areas of susceptible forest of high value.

It is encouraging to note how it has become possible to face up to a full blown epidemic in the forest—to note that while the forest has gained in value, the airplane evolved and became common. So also did the tractor and lately the inventiveness of man has extended to the synthesis of powerful insecticides notable among which is DDT. Thus has it become possible to put to use powerful tools, available for the first time in this region, in a time of insect epidemic.

It is perhaps out of place to discuss the possibility of success at the present stage of such a large scale forest protection venture.

The epidemic will undoubtedly subside. The unknown now is the date of its eclipse. Forest spraying keeps trees alive—of this there is no doubt. The outcome, then, unless some new trend appears, seems to depend mainly upon the relative persistence of the insect in epidemic form on the one hand and of the forest sprayers on the other.



### FAO ACTIVITIES IN GRAIN STORAGE AND STORED PRODUCT INSECT CONTROL<sup>1</sup>

H. E. GRAY<sup>2</sup>

The activities of the Food and Agriculture Organization of the United Nations are planned to accomplish two things, the solving of the problems of world food supply and the economic development of underdeveloped countries. One of the great needs at the time when FAO was organized was to make more food available to hungry people in many parts of the world. This was possible in two ways: to produce larger crops and to reduce the losses in present stocks. The first is slow and at best uncertain because of the dependence on weather conditions. The

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second would produce results much more quickly through the use of proved methods of storage and pest control. As a result, conservation of food grains through proper drying, storage, and pest control was stressed as a means of relieving the world food shortage.

### PROTECTING STORED FOOD

I was a member of an expert committee called together by FAO in Washington in May, 1946. In the report of the committee it was estimated that the annual world loss of food commodities from insect infestation amounted to about 5 per cent, that from rodents about 4 per cent, and that from mould fungi about 1 per cent, or a total of about 10 per cent. This is equal to the amount of foodstuffs entering into world trade. The elimination of such losses would do much to end the recurring threat of famine in many parts of the world. It was felt that the greatest reduction of losses could be brought about in all countries by: (a) drying the commodity, if necessary, for safe storage, (b) housing it in weather-tight, pest-free storage, (c) inspecting it frequently during storage and taking prompt control action when infestation is discovered, (d) using transport rendered free from insects and rodents, and (e) exporting only clean, uninfested foodstuffs.

### INTERNATIONAL MEETING ON INFESTATION OF FOODSTUFFS

The recommendations of this committee resulted in FAO calling an international meeting on infestation of foodstuffs in London in August, 1947. Twenty-seven countries were represented by 42 official delegates and 21 observers. There were formal papers, discussions, and visits to research institutions, storage warehouses, and industrial plants where methods of work could be studied. The recommendations adopted by the meeting were:

1. Member states should accept the principle that efficient prevention and control of food infestation is essential to the conservation of the world's food supply.
2. Member states should therefore maintain, or establish, adequate organizations for the prevention and control of infestation at all stages from farm to consumer, with special emphasis on storage, processing, and transport.
3. Special consideration should be given by all member states to the provision and training of the necessary technical personnel. Until more adequate staff is available progress will inevitably be slow.
4. The utmost use should be made of the various forms of publicity so that producers, handlers, processors, and consumers may be informed in the proper care of food.
5. Member states should collect information on the losses due to infestation and make the information available to FAO.
6. FAO should ensure that an appropriate information service is available to member states, and FAO should co-operate with such established institutions as those that are administered by the Council of the Commonwealth Agricultural Bureau, notably the Commonwealth Institute of Entomology and the Commonwealth Bureau of Mycology.
7. FAO should endeavour to arrange the loan of experts among member states for assistance in special problems.
8. FAO should arrange for regional collaboration of experts, such as that already operating in Europe, and also for periodic world conferences, for the joint consideration and exchange of experience and knowledge.

Much of the work of FAO in this field since 1947 has been directed to attaining these goals. It was necessary to focus the attention of the governments in many countries on the seriousness of the problem within their own borders. This was brought about by a series of meetings called by FAO at which experts discussed grain drying, food storage, and insect and rodent

control in food storages. Delegates of the countries represented at the meetings reported on storage conditions in their countries and on the losses sustained where such figures were available. These general meetings were frequently followed by more technical ones designed to train technicians in practical methods of control.

### REGIONAL MEETINGS

A regional meeting of specialists on controlling infestations in stored foods was held at the Station of Agricultural Entomology at Florence, Italy, in September, 1948. Ten European countries and Egypt participated and were represented by 24 delegates. In addition, Italy had 29 observers in attendance. The purpose of the meeting was an exchange of technical information on methods of controlling infestations in stored food, particularly in grain. The emphasis was laid on simple, practical methods, adapted to the small warehouse and to farm storage. The printed papers of the meeting in London in August, 1947, were supplied to those in attendance. In general, the same range of topics was covered in the Florence meeting; in addition to the discussions, there were numerous demonstrations, as well as field trips to warehouses, mills, and farm storages to view infestations and control measures under practical conditions.

The first of the regional meetings in Latin America was held at Palmira and Cali, Colombia, in February, 1949. This meeting was organized to focus the attention of responsible authorities on the magnitude of the problem within the area and the means by which pest control could be attained. The meeting consisted principally of the presentation of formal papers dealing with the control of stored product pests. Seventeen countries, including 12 from Central and South America, participated. The reports of the delegates indicated that enormous losses of foodstuffs were sustained annually because of inadequate control measures. The meeting recommended: establishment of pest control organizations in all countries; conducting of surveys of the distribution and abundance of stored product insects and rodents, and of the losses caused by them, where this has not already been done; and establishment of a standing committee of technical experts, one from each American country, to meet annually to deal with problems in the storage and preservation of grain and other food products.

A meeting on infestation in stored foods was held in San Jose, Costa Rica, in April, 1950. The purpose of the meeting was to demonstrate control measures, to establish direct contact between technicians from different countries, and to organize a committee on the preservation of stored foods. The aim of the committee was the free exchange of information by mail or by special meetings, and the conference was essentially a practical session for those responsible for pest control with the emphasis on "how to do it". Representatives from nine Latin American countries took part. The topics included grain storage on the farm and in commercial premises, grain drying, grain processing plants, warehouses, and the control of insects and rodents.

### ASSISTANCE TO UNDERDEVELOPED COUNTRIES

The various meetings sponsored by FAO stimulated a great interest in food storage and FAO received many requests for assistance on grain storage problems.

When a country requests assistance from FAO, the first step taken by the Organization is a survey of conditions within the area to be assisted. Frequently aid along a specific line is requested, yet an appraisal of the situation often indicates other, much more pressing needs. FAO is usually willing to initiate the projects requested by the country, but the FAO officers conducting the survey always discuss their finding with the government officials concerned and in many cases further projects are initiated as a result.

One of the greatest problems encountered by FAO is the need for integration of assistance. For instance, to provide more food a country may request assistance in setting up an irrigation project. This in turn involves technical assistance in agronomy, agricultural engineering, grain storage, and related activities. A development in one field makes apparent the need for help to deal with the many problems created by this development. After the increase in production



of foodstuffs comes the development of small industries within the country to provide things needed within the area. This raises the level of employment, which in turn increases the demand for consumer goods. As this process continues there is a gradual rise in the standard of living.

No reference to the stored product activities of FAO would be complete without mention of the work of Mr. Stephen S. Easter. He was appointed in April, 1947, as entomologist in charge of stored products and grain storage. In this capacity he visited a large number of countries, conducted many surveys of storage conditions, and made recommendations to the country concerned regarding future programs of work. One of the outstanding tasks carried out by Mr. Easter was in Nicaragua. He was called there early in 1951 at the request of the International Bank for Reconstruction and Development as a result of a request from Nicaragua for a loan to construct grain storage facilities. In a two weeks' period he conducted a survey of the situation, including the securing of the data needed by the Bank to judge the merits of the project. He helped the Nicaraguans to prepare a formal request for the loan. This was readily approved and the storage plant was in operation about two years after the original inspection was made. Normally the approval of such a loan requires about two years. It all sounds very simple but let us look behind the scenes for a moment. The size of the structure was important. It must be large enough to be economic but small enough to be efficiently used. Because of the two-crop system, the storage plant would be used twice rather than once annually and a smaller capacity could thus be used effectively. The size of the plant and the number and size of the bins were calculated on the basis of the types and quantities of grain and the time of harvest. Corn, beans, and sorghum are all important food crops in Nicaragua.

The location of the storage plant was relatively simple. Ten per cent of the population of the country is concentrated near Managua, and the population in the other areas is diffuse. Transportation costs are relatively high and the only system of railroads and highways radiates from Managua. As part of the set-up it was also recommended that a series of four drying stations to handle the wet harvest in August and September be established in the producing areas to at least partially dry the corn and beans before shipment to Managua for proper conditioning and storage.

I have dealt with some of the points we in North America would consider in building a storage. In examining the problem in the field, the FAO adviser must think of other matters such as national importance and the desire to keep up with one's neighbours. At times it is not easy to plan entirely on the basis of low cost and efficiency.

In many cases the first thing necessary is to provide the underdeveloped countries with technical assistance to increase their productivity and to develop their natural resources. This phase is carried out under the Expanded Program of Technical Assistance (ETAP). Its importance will be realized since in most of the underdeveloped countries from 60 to 70 per cent of the population are directly dependent upon agriculture. Such advice and training is a necessary forerunner of any financing of economic development.

About 200 FAO experts, drawn from 41 countries, are now working in 51 countries on a variety of projects. The program is being expanded continuously.

The motto of every FAO worker is "I must work myself out of a job as soon as possible". This is accomplished by training native workers to perform the tasks done by the expert so that they can take over and thus release the expert for other assignments.

In addition to the work of the experts in training native workers while on assignment within a country, FAO trains a large number from underdeveloped countries through their fellowship program. Fellowships are granted for periods up to one year for study in technically advanced countries to enable the trainee to carry on in his own country the work begun by the FAO expert. The fellows are chosen by the FAO expert, who often outlines the course of studies. Over 300 fellows from 27 underdeveloped countries have been or are being trained under this program in about 30 technically advanced countries.

## GRAIN STORAGE

Grain storage is a many-sided problem, with ramifications in the field of economics. In North America most of the grain is handled in bulk because we find it cheaper to do it that way. In many parts of the world, but particularly in the East, there is an over-dependence on the jute sack as a unit of storage. Many of those who use it fail to realize that the jute bag is a very poor storage unit. Jute sacks are very expensive and their life is short. In Pakistan, for instance, the annual cost was approximately \$5.00 per ton for replacement of the bags alone. This did not include the cost of the floors, sheds, warehouses, or coverings over the piles of jute bags nor did it include the serious losses sustained from insects and rodent when grain was so stored; jute bags are readily penetrated by these pests and afford ideal shelter for them. Until these facts are appreciated, little progress in the construction of better storages is likely. In some areas bags are rented for the storage of grain and those engaged in this lucrative trade are very much opposed to any change that would displace the jute bag. Changes will come slowly in such areas.

## COMMON GRAIN PESTS

Most grain storage pests are cosmopolitan in distribution. The principal pests encountered by FAO officers are: the rice weevil, *Sitophilus oriza* (L.); the granary weevil, *Sitophilus granarius* (L.); the confused flour beetle, *Tribolium confusum* Duv.; the red flour beetle, *Tribolium castaneum* (Hbst.); the saw-toothed grain beetle, *Oryzaephilus surinamensis* (L.); the flat grain beetle, *Laemophloeus pusillus* (Schönh.); the lesser grain borer, *Rhizopertha dominica* F.; and the cadelle, *Tenebroides mauritanicus* (L.). These and the various common species of dermestids and bruchids make up the bulk of the coleopterous pests. Among the moths, the Angoumois grain moth, *Sitotroga cerealella* (Oliv.), the Indian-meal moth, *Plodia interpunctella* (Hbn.), and the Mediterranean flour moth, *Ephestia kühniella* Zell., are the ones most commonly encountered. A species of beetle, *Pagicoerus frontalis* (F.), belonging to the family Scolytidae, is a serious pest of corn in Latin America, particularly in Ecuador and Columbia. It was one of the few stored product pests I had not seen elsewhere.

## INSECT CONTROL IN UNDERDEVELOPED COUNTRIES

FAO officers at all times stress the need for simple sanitation measures in the storage of grain and other cereal foods. In warm countries insects are everywhere. No only is it important to maintain the storage in a clean, insect-free condition but it is equally important to maintain the surrounding area in the same condition. It is often difficult to convince a warehouse owner in an underdeveloped country that he should do the latter to avoid invasion of his premises. The education of the general population in sanitation is most necessary but proceeds very slowly.

In contrast to the apathy often shown toward general sanitation, it is often possible to interest people in the underdeveloped countries in the use of modern control measures. The work in grain storage illustrates this to a remarkable degree. For the safe storage of grain the product must be dry, free of insect pests, and stored in facilities to maintain it in that condition. Much of the grain requires drying, an operation that can be carried out in mechanical driers or by exposure to the sun. Many of the governments in the underdeveloped countries are now building modern installations to deal with this problem. Alongside these modern plants are the old, unsanitary warehouses containing damp, spoiled grain, infested with insects and rodents. With time, no doubt, the old warehouses will be replaced by the newer, better types of storage.

To free grain from insect pests, fumigation is essential. Pure carbon disulphide is commonly used because of its low cost. This is never used in North America save in admixture with carbon tetrachloride, which reduces the fire and explosion hazard. When I was in Haiti on behalf of FAO early in 1953, I was able to persuade the entomologist to adopt the safer formulation. I also helped him design a new fumigation chamber and I was able to interest him in the use of methyl bromide as a fumigant.

At many of the modern grain storage plants in underdeveloped countries, methyl bromide is being used as a grain fumigant. This is carried out under plastic tarpaulins and in some cases

in grain bins equipped for circulation of the gas. The last procedure has developed because of the heavy freight charges on large-bulk fumigants. This technique is somewhat in advance of the procedures in use on this continent.

Many of the newer insecticides are now being used in many underdeveloped countries. For instance, in Haiti, BHC, DDT, chlordane and even parathion are used in field crop pest control. Warfarin is also being used widely in the control of rats in the field.

### A TYPICAL PROJECT

An outline of a specific project in one of the countries where FAO is furnishing assistance may be of interest. After the visit of Mr. Stephen Easter to Haiti in 1951, the Haitian government applied for technical assistance in carrying out a grain storage project. Because of the lack of dollars and through a desire to utilize native labour as much as possible, the government was most anxious that the storage facilities should be made of native materials.

FAO provided an engineer under ETAP to supervise the construction of three masonry bins, each of about 700-bushel capacity, one of double-walled concrete, a second of tamped earth, and a third of native stone. All of these storages were plastered inside and out so that externally they presented a uniform appearance. A period of aging was necessary to allow the structures to dry thoroughly before use. This required about six months. A fourth type of bin, a metal one of heavy galvanized iron, which had been imported from United States and which has been used widely in various parts of the world, was included in the tests.

I entered the picture in connection with the actual storage of the grain. Before beginning the work in the field, I was supplied with a brief outline of the project. After study, I prepared a detailed work schedule. Mr. Easter and I discussed the project while I was in Washington en route to Haiti.

On arrival in Haiti I discussed the project, how it would be carried out, and my requirements with the Minister of Agriculture, who had requested the technical assistance from FAO. Later I discussed the project in detail with my corresponding number in the Haitian Department of Agriculture and with other interested people. In my discussion with the Minister he was most insistent that we should store corn in one bin, sorghum in another, and beans in still a third. It required all my powers of persuasion to induce him to stay by the original idea of storing only corn. Otherwise we would have learned very little regarding the merits of the various building materials.

The storage program was to be carried on until the end of November, 1953. Then the bins were to be emptied and the corn examined to determine which of the four types of bins was most suitable for grain storage in Haiti.

The difficulties in carrying out technical assistance work are many and varied. I spent approximately three weeks arranging for a supply of corn for the storage experiments. Only part of the corn required could be purchased outright and arrangements were made for the loan of approximately one-third of the amount needed from a local grain merchant in Port-au-Prince. Most of the corn was brought from the Artibonite Valley and other places in the interior. The corn came forward to us very slowly. There were many delays.

All of the corn required fumigation as the entire supply was badly infested. This was done in Port-au-Prince and then the corn was hauled to the storage bins at Damien, a distance of five miles. Frequently we waited several days for it.

Much of the corn was so badly damaged by weevils that it was unacceptable for storage. As a consequence we hired a small army of women, who picked over about 300 bushels of it. The undamaged kernels were accepted and the damaged ones returned to the seller, who paid for the labour of sorting. To us such an operation is ludicrous; where labour is cheap it is a common place event.



All of the corn received was excessively moist. It was necessary to dry it before binning. As there are no mechanical driers in Haiti the drying was carried out by exposing the corn to the sun on tarpaulins in front of the experimental bins. Moisture determinations were made before binning to be sure that the moisture content was low enough for safe storage.

There are no mechanical grain loaders in Haiti either. The loading of the experimental bins was done by means of a "bucket brigade". Men on the ground filled pails with corn and passed them to other workmen on a substantial ladder, the top man pouring the corn into the bin. To dry and load five tons of corn in a day was a real accomplishment.

Supplies of all kinds were difficult to acquire. We needed a small amount of lumber on which to install a series of thermocouple junctions. To procure the necessary material took over a month. Fortunately I found another source of supply and replaced the borrowed stock when the lumber ordered by the government finally arrived.

These are the normal difficulties one must expect in work of this kind. I took most of the tools I required with me and without them the project could not have been completed.

Labour is abundant in Haiti but it must be closely supervised. Aside from the technical knowledge, an FAO expert must have a never-ending supply of patience and a well-developed sense of humor. He needs both at all times if he is to make any progress.

This study covered only one phase of grain storage. In addition to the large-type bins experimented with, there is a very definite need in Haiti for storage facilities for farmers to protect the grain they store for their own needs. These should, of course, be small structures and if possible they should be built or at least assembled within the country.

What has been accomplished in the field of grain storage in Latin America? Considerable progress has already been made through the activities of FAO, of the Inter-American Institute of Agricultural Sciences at Turrialba, Costa Rica, and commercial firms such as Colombian Steel Tank and Butler Manufacturing Company of Kansas City, Mo.

In 1948 there was one single modern grain storage plant in San Jose, Costa Rica. Plans were under way for some construction in Venezuela, and nothing had been done in Colombia save by the Bavaria Breweries Corporation. There were no modern grain storages in Mexico, Nicaragua, Honduras, El Salvador, Guatemala, Haiti, Panama, or the Dominican Republic. Today there are several modern storage plants in Mexico at various points throughout the country. There are now 27 operating plants in Venezuela, with a total capacity of 63 thousand metric tons, and 8 in Colombia and 6 more under construction. Almost all of this development in modern grain storage can be credited to the increased interest in the storage of food developed by FAO programs.

In conclusion, I would say that FAO has accomplished much since it came into existence. Progress in many cases has been slow but this can be changed only by education. There will be a need for the work of FAO for many years to come. Each problem solved in an underdeveloped country brings to light the need for assistance in solving others. The standard of living in these areas can be raised to a desirable level only through an integrated program of assistance.

FAO makes a big contribution to world peace and goodwill that is often overlooked. Her experts, working with the people in underdeveloped areas, show the way for true co-operation in helping those in need of assistance. They do much more to dispel suspicion and create goodwill at all levels than the average diplomat.

## CONTROL OF INSECT VECTORS OF DISEASE BY W.H.O.

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In 1939 Paul Muller discovered the insecticidal effect of DDT on houseflies; in 1948 he was awarded the Nobel Prize for Medicine for the outstanding contribution of DDT to human health in the tropics. Since DDT had the remarkable property of killing insect vectors merely by being picked up from treated surfaces, control measures could be undertaken which consisted of simply spraying the interior walls and ceilings of dwellings.

The World Health Organization was quick to realize the potentialities of the method in the control of malaria, a mosquito-borne disease which in its various forms is responsible for more illness and poverty than any other disease, and has been estimated to produce one-half of the entire mortality of the human race. By 1948 WHO had set up a Malaria Section at Geneva, and at the end of 1953 twenty-seven malaria control demonstration teams were, or had been in the field in Afghanistan, Bolivia, Brunei, Burma, Cambodia, the Caribbean Area, Cameroon, Dominican Republic, Formosa, India (Jeypore Hills, Malnad, Malabar, Terai), Indonesia, Iran, Iraq, Haiti, Liberia, Lebanon, Pakistan, Paraguay, Philippines, Sarawak, Saudi Arabia, Syria, Thailand, Vietnam, of which 20 were still in the field in December 1953, plus one WHO malariologist working with UNRA in Jordan and Lebanon. These teams conduct demonstrations or study particular problems such as those presented by vectors which are said not to frequent houses sufficiently to be controlled by residual insecticides, and in all cases train national personnel in malariology and modern methods of control, so that after two years the host countries may take over. In addition, WHO furnishes malaria consultants to many countries. Through its expert committee on insecticides, it has established specifications for chemicals and application equipment. It annually canvasses the world supply of DDT, and encourages the erection of DDT manufacturing plants in key tropical countries, such as India. WHO has convened malaria conferences in Africa and in South-East Asia to bring workers from those regions together. By the promotion of malaria control in the various countries, it has set as its ultimate goal the eradication of malaria as a public health problem.

What of its success? In Italy, where the Roman Campagna, the Tuscan Maremma, and to a lesser extent the Po valley, had been notorious malarious areas since classical times, and where land had been abandoned because of the disease: in this entire country now there has not been a single death from malaria since 1949. Around Latina, Mussolini's town in the drained Pontine Marshes, where under the German occupation 90 per cent of the 100,000 people in the district had malaria, there has not been a single new case since July 1949, and not a single specimen of the vector *Anopheles labranchiae* has shown up in samples since March 1949. In Sardinia at the beginning of the century, everybody had experienced malaria. A programme of house spraying was commenced in 1946 and succeeded in almost eliminating *Anopheles labranchiae*; so that by 1949 there were no cases of primary malaria on the island.

In Greece, house and barn spraying, supplemented with larviciding from aircraft, was started in 1946. By 1950 it had been so successful in reducing the vectors *A. sacharovi* (*elutus*) and *superpictus* that malaria had become "practically" eliminated; there were very few cases in the country last year. The island of Cyprus, containing half a million people, was treated during the same period at a cost of \$600,000; in 1950 the Cyprus Government was able to announce that malaria had been eradicated from the colony.

In Ceylon, where new cases ran to 3½ million people in 1940, and deaths to 80 thousand in 1934, house spraying was started in 1946 against *A. culicifacies*. Three years of 7 sprays per

<sup>1</sup>The author is indebted to Dr. E. J. Pampana, Chief of the Malaria Section, and to Mr. J. W. Wright, Secretary of the Expert Committee on Insecticides, for their kindness in reviewing and amending the manuscript on behalf of the World Health Organization.

annum succeeding in reducing the spleen rate (a diagnosis of incidence) from 77 down to 2.7 per cent. In Bombay State, in the same year, a population of 5 million people was protected by 3 sprays per annum applied against *A. culicifacies* and *A. fluviatilis*. As a result the annual malaria incidence was decreased by 300,000, and the spleen rate fell from 70 down to 7 per cent. In northern Siam a campaign against *A. minimus* started in 1949 decreased the malaria morbidity rate from 50 down to 2 per thousand within 2 years.

The island of Mauritius in the northwestern Indian Ocean has been a notorious region for malaria, which is transmitted by the African species *A. funestus* and *A. gambiae*. A single spraying by the Colonial Government in 1949 reduced *A. funestus* by 99.9 per cent, and the surviving *A. gambiae* were cleaned up by larviciding. Malaria parasite rates dropped correspondingly sharply.

In 1947 the Colonial Government of British Guiana started large-scale house spraying against *A. darlingi* in the coastal areas. It has been so successful that in certain parts of the capital, Georgetown, where malaria parasite rates were 55 per cent, they are now nil. In Venezuela the inhabitants of the vast Llanos region had spleen rates of 80 to 100 per cent; house spraying against *A. darlingi* from 1947 to 1951 has reduced this malaria incidence rate to a level of 3–16 per cent. In Brazil, more than 3 million dwellings, infested with this species, have been treated between 1947 and 1950, and the parasite rate has been reduced to zero in most areas. In coastal Peru, control of *A. pseudopunctipennis* has brought parasite rates down from 7–25 to 0–0.6 per cent. In Argentina, where 300,000 new cases occurred yearly before 1947, malaria no longer constitutes a serious health problem in 1951.

Similar successful programmes have been carried out, and reports of results are now available from Spain, Yugoslavia, Turkey, Iran, Pakistan, Afghanistan, Indonesia, Madagascar, Nigeria, Belgian Congo, Rhodesia, Transvaal, French Guiana, British West Indies, Colombia, Bolivia, Ecuador, Chile and Mexico. Today well over 50 million people depend for their life and livelihood on DDT spraying. The cost of these measures approximates 20 to 50 cents per capita, less than the anti-malarial drugs (mainly synthetic analogues of quinine) which they render superfluous.

These programmes have also produced some striking bonus dividends. The operation in northern Siam ended an endemic plague of bedbugs. The Mauritius and British Guiana operations eliminated also the yellow fever mosquito, *Aedes aegypti*, and in British Guiana went a long way towards eliminating *Culex quinquefasciatus*, the vector of filariasis. The programme in Bombay State eliminated plague, as a consequence of the incidental control of rat fleas. In Greece, antimalarial operations resulted in the elimination of *Phlebotomus* and the consequent eradication of sandfly fever from that country. It also has greatly reduced leishmaniasis. In all the Mediterranean and Middle East countries, anti-malarial sprayings were at first rewarded with a striking decrease in abundance of the housefly and in the fly-borne dysenteric diseases.

These residual spraying operations are carried out by a large force of unskilled and cheap labour; in Sardinia for example, 12 technicians directed a force of 33,000 workers. In most instances a 4-gallon pneumatic sprayer is used, with a flat fan nozzle to give a coarse spray with a 5 per cent DDT formulation. The dosage recommended by W.H.O. is a deposit of 200 mgms. of DDT per square foot (2 gm./sq. metre) applied every 6 months. In India and Ceylon, less is used at more frequent intervals. Originally a solution of DDT in kerosene was employed. Now in the Mediterranean countries, and some others, an emulsion is used. In Italy, for example, the worker sets out on his bicycle with his sprayer and a jerry-can of concentrate, to which he adds water from domestic sources.

In certain regions, notably Mexico, Morocco, and East Africa, it was found that house spraying with solutions gave poor results. It was discovered that the walls of the dwellings, which were of mud, adsorbed the DDT into their pores. This was circumvented by the use of suspensions of wettable powders (usually 50%, though 75% WP's are now being tried), and these have been adopted in Africa and parts of South America, and recently in India. A further difficulty was encountered in central Africa where the principal vector is *A. gambiae*. This is a restless



species, often apt to take to the bush rather than remain in houses, and on it DDT had a so-called repellent effect, in that this mosquito became excited and flew away before it had taken up a lethal dose. Consequent on a W.H.O. conference in Uganda in 1950, the substitution of BHC was recommended, to be applied every 3 months at the rate of 10 mgms. of gamma-BHC per square foot. The odour is conspicuous, but is reassuring rather than offensive. A problem similar to that of *A. gambiae* is presented by the stream-breeding *A. minimus* of Malaya and the Philippines, which does not settle readily on walls; and *A. sergenti* of Israel evidently similarly escapes the action of DDT.

One of the results of anti-malarial spraying is that it may increase the food supply. Operations in Bengal were responsible for increasing the rice crop by 15 per cent and malaria control in Greece has allowed the safe introduction of rice cultivation to that country. In Greece since 1950, tests have been made of the effect of suspending DDT spraying; this did not degrade the epidemiological picture in 1951, but in 1953 cases of malaria reappeared in certain villages. However in Crete it appears that the mosquitoes can be allowed to recover without malaria recurring, and that the desirable condition has been attained of "anophelism without paludism", such as we have had for the last half-century in Canada and Britain.

Other control operations against insect vectors include a campaign against kala-azar and oriental sore in Italy, where house spraying at 25 cents per capita completely destroyed the three species of *Phlebotomus* concerned, and stopped the transmission of these leishmaniasis. Control of black flies of the genus *Simulium*, vectors of the filarian worm that causes onchocerciasis of the skin and eyes, was first shown to be possible in Guatemala, where the larvae were eliminated by adding DDT to the water. Similar results were obtained for *S. neavei* in Kenya, while BHC is used for control of *S. damnosum* in the Congo and the Gold Coast. The control of the various species of *Glossina* (tsetse flies) in Africa is mainly a veterinary problem, namely Nagana disease of cattle, although the trypanosome still causes sleeping sickness of man in West Africa. Experiments in East Africa, where cattle raising is the native's main source of livelihood, have shown that multiple aerial sprayings (eight or nine times) with DDT at 0.25 lbs. per acre can achieve almost complete control. Anson aircraft are used for this purpose, the original exhaust aerosol units being now replaced by boom-and-nozzle assemblies, although rotary brushes are being tested. Control of *Triatoma*, the conenosed bugs responsible for transmitting Chaga's disease, has been undertaken in the tropical Andean countries, first with DDT, and later more successfully with BHC and dieldrin. Finally there is the well-known ability of DDT powder to avert typhus by the control of body lice, dramatized by the complete arrest of the epidemic in Naples in January, 1944.

We are all familiar with the promise of DDT ending the scourge of the housefly, vector of cholera, summer diarrhoea and other dysenteries, associate of poliomyelitis, and producer of trachoma and conjunctivitis of the eyes; how promising it was initially in Italy and the Middle East, and how whole cities such as Cairo, Manila and Singapore were sprayed from the air to prevent post-war epidemics. Then resistance was found in Italy in 1946-7, in the U.S.A. in 1948 and Canada in 1949, and now it is present in places all over the world, and is so intense in regions like Florida, California and Syria that DDT is entirely ineffective. We need scarcely remind you that this resistance is the result of Darwinian selection of resistant survivors, that it depends on the accumulation of multiple recessive genes, that it reaches full development around the 12th to 18th generations and thus appears sooner in regions of multivoltinism, and that it stems from contamination of large areas, particularly the breeding places, with sublethal dosages. We all know that these resistant strains, most of which now roost on floors instead of walls and ceilings, can detoxify DDT by converting it to DDE by the process of dehydrohalogenation, a process found in other species of insects which are normally resistant to DDT. More recent is the discovery that certain synergists, like the piperonyl compounds, can inhibit this detoxification, while others such as DMC may act as decoys for the detoxification process while the DDT is left alone to do its insecticidal work: but unfortunately after half-a-dozen generations resistance is acquired to the DDT-synergist mixture. Resistance of the housefly to BHC was first discovered in 1949 in Egypt, to chlordane in Sardinia in the same year, and to dieldrin in California in 1951.

Now it is known that DDT-resistant flies may be expected to be resistant also to methoxychlor and DDD, and to acquire within a very few further generations resistance to BHC, dieldrin and other chlorinated hydrocarbons. Even by 1951 it was useless to apply any of these insecticides in the refugee camps of the Levant. Dr. Luther West, sent by W.H.O. in 1952 to investigate fly resistance problems in the eastern Mediterranean, reports that in the UNRA camps of Syria, Lebanon and Jordan the monthly (October) incidence of dysenteries was as high as 7,024, and of the eye diseases 65,756, as against a total of only 4,258 for all other diseases, including malaria. Truly the housefly and fly-borne diseases now pose the most serious problem confronting medical entomologists. In many parts of the world housefly resistance is handicapping anti-malarial spray programmes, since the population had co-operatively supported them only so long as they controlled the flies.

Fly control measures are now taking a different turn. In Italy stress is now laid on sanitation and garbage disposal; in Egypt and Israel on the rendering of human and cattle excrement unsusceptible to breeding; in America we have the Big Stinky fly-trap. Chlorinated hydrocarbons are still used but in different ways, such as lindane vaporizers, dieldrin-coated screen strips and DDT-containing resin coatings based on urea-formaldehyde or terphenyl mixtures. Non-dehydrochlorinatable compounds such as pyrolan and dilan originally appeared hopeful, but have ultimately proved inadequate. For those that can afford it, synergized pyrethrins and allethrin may be used as residual sprays. Meanwhile the organic phosphates offer the most promising avenue and many stratagems have been devised with them, such as festoons of parathion-impregnated twine, and the tracking of stable floors with a solution of TEPP and molasses from a watering-can. Malathion in 1 per cent solution, applied at 50–100 mgms. per square foot on exterior surfaces, has given control for 10 to 14 days, and so has diazinon. In Europe, boughs (fagots) moistened with diazinon or malathion solution are hung up in houses, but they require toxicological clearance before general use. It may therefore be seen that housefly control by chemicals has retrogressed considerably in the last 7 years.

What of resistance in other species of disease-carrying insects? It may be stated at the outset that the anti-malaria campaigns with DDT have nowhere yet been appreciably handicapped by this phenomenon. It is true that DDT-resistance in *Culex pipiens* was found in Italy in 1947, in *C. tarsalis* in California in 1951, and has been suspected for *C. molestus* in Greece and *C. fatigans* in Venezuela. It is also true that DDT-resistant *Aedes sollicitans* and *taeniorhynchus* are present in Florida, and resistant *A. nigromaculis* and *dorsalis* in California. But resistant *Anopheles* have been slow in appearing, and the level of resistance is low. In Greece *A. sacharovi* and *maculipennis* are now apparently more resistant than formerly, and this is also reported for *A. superpictus* in Turkey, *A. albimanus* in Venezuela, and *A. quadrimaculatus* in Alabama. In some areas of South America *A. darlingi* is resisting control by DDT, but not in others. In Nigeria and Uganda *A. gambiae* may be acquiring a behaviouristic resistance of no longer resting inside houses.

The alarming appearance of DDT-resistant strains of the body louse in Korea created a serious problem among prisoners of war. This resistance has now been reported also from Italy and Japan. DDT-resistance has been discovered in the oriental rat flea (the vector of plague) in South America, in the human flea in Greece, and in the dog flea in the U.S.A. Resistance to DDT has recently developed in *Triatoma infestans* in Chile. German cockroaches resistant to chlordane and lindane are now present in various parts of the U.S.A. DDT-resistant strains of the bed bug are now reliably reported from Greece and the Belgian Congo as well as Hawaii and the continental U.S.A. *Phlebotomus* sandflies have not yet shown resistance to DDT, an erroneous report of resistance in Greece having originated from the first-hand observers confusing *Psychoda* with it. *Musca vicina* and *M. nebulosa* in India have not yet shown the resistance characteristic of *M. domestica*. The fleshflies *Phormia* and *Phaenicia*, and the screw-worm flies of the genus *Callitroga*, have not developed resistance either in the field or the laboratory.

In the most recent conference of W.H.O., held in Rome three weeks ago, plans were laid for the systematic testing in the field for the appearance of resistance, and particular attention was paid to the development of substitute methods of control where resistance develops. The im-

portance of acquiring basic knowledge in the associated physiology and genetics were vividly realized. Meanwhile it is a matter of congratulation that in the decade since 1942 some 5 million deaths and 100 million illnesses have been prevented by the use of DDT, not to mention the future benefits which will accrue from the general reduction in malaria density. We can agree with the Nobel committee's opinion in 1948, and we are proud that entomologists have played so important a part in this epoch-making contribution to the well-being of mankind.



## A HISTORY OF GRASSHOPPER OUTBREAKS AND THEIR CONTROL IN MANITOBA, 1799-1953

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### *History of Outbreaks*

Of all the field crop insects that occur in Manitoba, grasshoppers are the most destructive. More farmers have been involved and more money and energy have been expended on their control since settlers first arrived in this Province, than on any other group of crop infesting insects. Wheat, oats and barley have been injured most, although other field crops, vegetable crops and even the leaves of trees have been eaten. Grasshoppers have occurred in outbreak form over most of the agricultural lands of Manitoba at one time or another although crops in that part of the Province south of the Riding Mountains and the southern ends of Lake Manitoba and Lake Winnipeg have been attacked most severely and frequently. Grasshopper outbreaks have occurred intermittently during the last century and a half and no doubt will continue to occur in the future.

The first recorded occurrence of grasshoppers in Manitoba was in 1799, according to Pritchett (1942), who says that grasshoppers had appeared in the Red River Valley some thirteen years before the arrival of the Selkirk settlers which was in 1812. Grasshoppers had then disappeared to return in 1818 on a date late in July. Coues (1897) quotes from the journal of Alexander Henry of Aug. 17, 1800 with reference to the "east shore of Lake Winnipeg, six leagues from the mouth of the Red River" to the effect that, "The beach was covered with grasshoppers which had been thrown up by the waves and formed one continuous line as far as the eye could reach; in some places they lay from six to nine inches deep, and in a state of putrefaction which occasioned a horrid stench."

Grasshoppers again invaded at least the area around the mouth of the Pembina River in 1808. Coues again quotes from Henry's journal of July 25, 1808 to the effect that, "Swarms of grasshoppers (the Rocky Mountain locust, *Caloptenus spretus*) have destroyed the greater part of the vegetables in my kitchen garden — onions, cabbage, melons, cucumbers, carrots, parsnips and beets. They also attacked the potatoes and corn but these were strong enough at the root to sprout again. The swarms appear about the 15th of June, generally in clouds from the S., and spread destruction; the very trees are stripped of their leaves. Grasshoppers pass northward until millions are drowned in Lake Winipic and cause a horrid stench as I have already observed (Aug. 17, 1800). They do not make a formidable appearance every year."

The next invasion was in 1818 and of this Pritchett says, "In the morning the gardens and the fields of grain promised an excellent harvest. In the afternoon the sky was darkened by locusts in vast swarms, sweeping in from the great dry regions lying to the south and west; and next morning when the people awoke, all their hopes were blighted." The grasshopper or locust invasion in 1818 in the Red River Valley was a major disaster to the Selkirk settlers. Morton (1939) quotes from Alexander Macdonell's (Lord Selkirk's agent) report to Lord Selkirk, "millions of grasshoppers invaded our crops and eat up all our barley and potatoes—not



a vestige of them left, but all the potatoes on the plains suffered very little injury; the barley have been eat up everywhere—The wheat has not been injured in the least as yet." Apparently at that time all the garden vegetables were devoured. Morton again quotes from the record, "The year 1819 proved one of disaster for the colony. The grasshoppers had laid their eggs in the soil the summer before. On 3rd May the young brood made its appearance. They came out of the ground like froth out of the bung of a cask full of fermenting fluid.—Everyday until the middle of June brought forth fresh myriads of new-born ones. The larvae devoured the young crops, leaving not so much as a particle behind them." Young grasshoppers did not seem to be very numerous early in 1820 but there was an invasion of adults on July 25 of that year. In 1821 the destruction of crops was not general but was severe in restricted areas. During the latter part of July of that year the grasshoppers left before a strong northerly wind.

The early settlers had time to forget about the ravages of grasshoppers for it was not until 1857 that there are records of their reappearance. After speaking of the 1819 and 1820 invasion Dawson (1875) says, "The next recorded incursion is that of 1857—. In 1857 the crops are said to have been so far advanced as to escape great damage, but eggs were deposited and in 1858 all the young grain was devoured."

Beginning in 1861 there followed a decade when grasshoppers were present every year. Dawson says, "In 1864 they again appeared and left their eggs, but neither the adults nor the young of 1865 were sufficiently numerous or widespread to do much damage. In 1867 numerous swarms poured in but did little injury, the crops being too far advanced. Their progeny in the ensuing spring however devoured everything causing a famine." Morton observes that the young in 1868 ate everything green. This necessitated the Council of Assiniboia voting 1600 pounds sterling for relief. Another 5000 pounds were raised in England, another 3600 pounds raised in "Canada" and another 900 pounds in the United States. This emphasizes the widespread publicity that must have been given to the plight of the people and to the seriousness of the situation. Dawson continues "They again appeared in 1869, the young in 1870 doing much harm. In 1872 fresh swarms arrived but as usual, too late to do much damage to wheat. Eggs were left in abundance in the northern part of the Province and in the following spring the farmers over considerable districts did not sow. In 1874 winged swarms again came from the west arriving earlier than usual and inflicting great injury in some districts. Eggs were deposited in almost all parts of the Province and result has yet to be seen."

Dawson's observation, "It is now known that a very great area comprising the chief breeding grounds of the locusts must always remain unsettled or occupied only as pasture grounds" is most interesting. Other interesting observations made by Dawson include statements that the eggs are laid in high and dry situations with hard soil, that the grasshoppers fly only in sunlight and during the warmer hours of the day, that in the eastern colonies the young are sometimes hatched in considerable numbers by a mild autumn and perish in the succeeding winter and that their range included the whole province of Manitoba. He suggested as control measures the firing of prairie grass after hatching, fall plowing where eggs have been laid and gathering the eggs and receiving government bounty by measure for the eggs collected, the use of heavy rollers on the young, and driving young into straw which would be burned. Apparently these are the first recorded recommendations for the control of grasshoppers in Manitoba. He says, "species of grasshopper appear to belong to a single species which has been called *Caloptenus spretus*." This species was later given the name of *Melanoplus spretus* Uhler.

Hargrave (1871) says, "the harvest of 1867 was considerably injured by the vast clouds of grasshoppers that lighted at the beginning of harvest. Almost all oats and barley were entirely destroyed, the wheat greatly injured. The other sources whence food is principally obtained for the subsistence of the colony gave their accustomed yield." With regard to 1868 Hargrave says, "The multitude of insects was so great as to render it difficult to convey an appreciable idea of their numbers to the minds of those absent from the scene of their devastations. Piled in heaps about the walls of Fort Garry, they were carted away and burned up to prevent the effluvia from their decaying bodies contaminating the atmosphere during the stifling heats of an unusually warm summer."

Huyshe (1871) speaking of the early grasshopper invasions in Manitoba says that, "they come about the middle of July or the beginning of August from the south-west towards the north-east in dense clouds so that the land is darkened with them and wherever they alight they make a desert eating up every blade of corn and grass and stripping the trees of their leaves." He says that their eggs hatch about the first week of May no matter how severe the winter. Speaking of the 1868 outbreak he says that they came in, "such countless myriads that they were lying piled up against the angles of the bastion and walls of Fort Garry to a depth of three feet. The stench from their dead bodies was almost unsupportable and they had to be carted away and thrown into the river." There followed a period of approximately a quarter of a century during which no serious invasions or outbreaks of grasshoppers occurred and it was not until 1898 that next we hear about them.

Fletcher (1898) says, concerning 1898, "During — June notices appeared in the newspapers that injury was being done by grasshoppers or locusts in southern Manitoba. These reports naturally caused much anxiety among the old settlers who had been in the Prairie Province at the time of the serious locust depredations during 1868, 1870, 1872 and 1874." In the same report he says that he visited the grasshopper infested localities that year in Manitoba and that "none of the farmers with the exception of Mr. John Scott, remembered seeing locusts in injurious numbers before." No doubt these somewhat conflicting statements may be explained by the fact that these earlier outbreaks occurred in the Red River Valley. In any event by inference it would seem that there had been no serious outbreak of grasshoppers between the years 1874 and 1898. In 1899 Fletcher (1899) says that grasshoppers were not bad but that they appeared in some numbers in southern Manitoba. Fletcher (1900) in making his annual report for 1900 says, "It will be noticed that the area infested was not the same as that which was invaded by locusts north of the Turtle Mountains during the two previous summers." Concerning the 1900 outbreak he says, "Seeing hundreds of acres in some places swept bare, I expected to find large swarms of the Rocky Mountain locust, *Melanoplus spretus* Uhler, but at only one place was this insect detected and this was at Douglas. The species which were almost entirely answerable for the destruction of crops in Manitoba in 1900 were the native species *Melanoplus packardii* (Scudd.), *M. atlantis* (Riley) and *Camnula pellucida* (Scudd.)." The species *M. atlantis* Riley has since been named *Melanoplus mexicanus mexicanus* (Sauss.) solitary phase. There is little likelihood that Fletcher confused the identity of *M. packardii* (Scudd.) with *Melanoplus bivittatus* (Say) which he apparently knew and which in later years became an important species of economic importance in Manitoba. Fletcher included in his report notes made by Norman Criddle who lived near Treesbank to the effect that in 1900 hatching began April 24 and most of the eggs were hatched by May 8 while several fields were cleared off by May 14 at Aweme, but some eggs were still hatching. By June 6 that year half of the grasshoppers could fly. On June 20 the locusts were flying south-west and were identified as *M. spretus* Uhler and *M. atlantis* (Riley). By June 27 the locusts had nearly all disappeared. Fletcher quotes Criddle as saying, "the locusts had been increasing here for about three years, in fact considerable damage was done in the latter part of 1899." Fletcher says that *M. atlantis* and *C. pellucida* were the most abundant species throughout the province in 1900. The appearance of local species in outbreak form was apparently surprising to both Fletcher and Criddle, the latter of whom says, "It is to be hoped that this was merely an exceptional outbreak of local species which will not recur next season."

Fletcher (1901) reported that grasshoppers caused considerable loss that year particularly in Central Manitoba in the Treesbank area and also around Morden, Altona and Chortitz. Mr. S. A. Bedford, superintendent of the Experimental Farm, Brandon wrote to Dr. Fletcher, "Grasshoppers by millions were on roads" near Sewel. These were identified as *M. atlantis* (Riley). The situation was so bad that Fletcher came to Manitoba and began an investigation. He reported to R. P. Roblin, Manitoba Government, on July 6 stating that while *M. atlantis* was most abundant, *Camnula pellucida* and *M. bivittatus* were also present but in smaller numbers. At Plum Coulee some *M. spretus* were found mixed with *M. atlantis*. At Fairfax he found *M. spretus* in enormous numbers all mature on July 4. The outbreak continued in 1902, according to the report of the Manitoba Legislative Assembly for that year. In the similar report for 1903, Criddle is quoted as saying, "nearly all the damage (which did not amount to much) was the result of

carelessness." The outbreak then subsided and grasshoppers were not a problem in Manitoba again until 1919.

The writer has been at The University of Manitoba, Winnipeg continuously since 1918 and has been involved in the four grasshopper outbreaks which have occurred since that time. In the extreme southwestern part of Manitoba the first grasshopper damage in 1918 passed almost unnoticed. In 1919 the infested area was considerably enlarged and control measures were undertaken quite extensively. It was not until 1920, however, that the infestation assumed alarming proportions in the municipalities of Edward, Arthur, Brenda, Winchester, Albert, Cameron and Pipestone. Scattered outbreaks occurred in other widely separated municipalities. In 1921 the outbreak continued with a further extension of the infested area but still was confined largely to the western half of Manitoba south of the Riding Mountains. In 1922 the severity of the infestation diminished and in 1923 it was localized in only one or two relatively small areas. Mitchener (1921) stated that the grasshoppers, as now named, involved in this outbreak were *Camnula pellucida* (Scudd.), *Melanoplus mexicanus mexicanus* (Sauss.), *Melanoplus femur-rubrum* (Deg.) and *Melanoplus bivittatus* (Say). As many as seventy-five eggs pods of *C. pellucida* (Scudd.), averaging around twenty eggs each, were found in places to each square foot of sod. The first two species named were most abundant. No Rocky Mountain locusts were observed at any time during this outbreak. Grasshopper baits were used very extensively throughout the infested areas with excellent results. The fact that 185 farmers called at and received from one mixing station 39,800 pounds of prepared bait on June 15, 1920 will give some idea of the effort that was put forth by the farmers to bring the infestation under control. Mitchener (1921) estimated that crop to the value of over 17 million dollars was saved by the organized control that was carried out in 1920. McKay (1922) in a report to his Deputy Minister stated that approximately 85,000 pounds of arsenic, 580 tons of bran and 378 tons of oatfeed were used in the 1921 control campaign in Manitoba.

The next outbreak began to build up in 1929. Mitchener and Criddle (1929) say that "*Camnula pellucida* (Scudd.) increased to a marked degree in 1929." These same authors (1931) say that in 1930 grasshoppers "are increasing in numbers." — "It is possible that in a few restricted areas crops may be injured next year." Again they (1932) say, "There was a very marked increase in the numbers of grasshoppers in 1931 particularly in the eastern agricultural area centering on the Red River Valley where grain crops were badly injured." Mitchener (1933) reported, "During the summer of 1932 Manitoba experienced an extensive and severe outbreak of grasshoppers." A map in the above paper indicating the area under attack during the year shows that more than half of the cultivated land in the Province was involved with the heaviest infestation in the Red River Valley. The outbreak became less severe progressively to the west in the southern part of Manitoba to which the outbreak was almost entirely confined. Mitchener (1934) showed that much the same area was involved in 1933 with the Red River Valley again most heavily infested. Mitchener (1935) showed again by means of a map that the area under grasshopper attack in 1934 was approximately the same as in the three previous years with heavier damage moving towards the southwestern part of Manitoba. The Red River Valley continued to be relatively heavily infested. Mitchener (1936) showed in 1935 that although approximately the same area of Manitoba was under attack, the severity of the infestation was diminishing. Mitchener (1937) reported, "that practically no bait was used to control grasshoppers in Manitoba in 1936." In 1937 grasshoppers were quite widespread in southwestern Manitoba although farmers did relatively little poisoning as only about 17 tons of prepared bait were used altogether in the municipalities of Arthur and Edward. The lesser migratory grasshopper was the predominant species in 1937. During 1938 damage continued relatively light in approximately the same area of the Province. In 1939 the infestation was more widespread and severe, but still confined to the southern part of the Province. Grasshoppers increased in numbers in 1940 with the heaviest infestation in the southwest. In 1941 the area infested was greater than in the previous year with greater concentrations occurring in the Red River Valley and north of Winnipeg between Lake Winnipeg and Lake Manitoba. The area infested in 1942 was about half as extensive as in 1941 but control measures were still necessary. Grasshoppers were so reduced in numbers in 1943 that no control measures were necessary. Relatively low populations



of grasshoppers continued during 1944, 1945, 1946, 1947 and 1948. It became evident during the summer and autumn of 1948 that grasshoppers were again finding conditions favourable for their increase and the prediction was made that they would be destructive in 1949. During the summer of 1949 grasshoppers were present in greatly increased numbers necessitating an active control campaign. This outbreak continued in 1950 and was largely confined to the Red River Valley where it was severe. Control was still necessary in 1951 although the area involved was less than in 1950. The outbreak continued to decrease in 1952 although some control was needed. There was no call for any insecticide at all in 1953 when grasshopper populations were again at a low point.

The grasshoppers involved in the 1931-1935 Manitoba outbreak were the clear-winged grasshopper, *Camnula pellucida* (Scudd.), the two-striped grasshopper, *Melanoplus bivittatus* (Say) and the lesser migratory grasshopper, *Melanoplus mexicanus mexicanus* (Sauss.). Criddle (1933) in his studies on the habits of grasshoppers found from limited observations that the female clear-winged grasshopper laid about 150 eggs, the two-striped grasshopper approximately 217 eggs and the lesser migratory grasshopper about 160 eggs during their respective lives. He stated that grasshopper eggs may remain under water for weeks and still hatch when the land dried out. This observation has been confirmed by the writer. He believed that most species reach the adult stage within 40 days after hatching. He reported that the clear-winged grasshopper feeds largely on members of the grass family while the two-striped grasshopper and the lesser migratory grasshopper are capable of feeding on a great variety of plants.

#### History of Control

Although Dawson suggested some mechanical methods of controlling grasshoppers, it was not until the beginning of this century that poison began to be used to destroy grasshoppers in Manitoba. During the years 1901 and 1902 the Manitoba government supplied paris green free to those farmers who would use it. This was used in baits which were scattered on the ground where the grasshoppers occurred. Bran was used as a carrier for the paris green. Norman Criddle recommended fresh horse manure as a carrier but this was used locally and only to a very limited extent.

In 1919 a bait known as the Kansas Bait containing bran, paris green, molasses, lemons or oranges and water was used. As the years passed experimental work in Manitoba showed that bran and sawdust mixed half and half gave good results as a carrier. Then citrus fruits were omitted and amyl acetate was substituted as an attractant. Salt next replaced the amyl acetate. White arsenic subsequently took the place of paris green. It was found that salt was not necessary and it was then omitted from the bait so that the mixture was made up of bran, sawdust, white arsenic and water. Later, sodium arsenite superseded white arsenic and cheap flour was added to the sawdust which mixture replaced the bran and sawdust. As long as baits were used continuous attempts were made to lessen the cost of the baits and still have them retain their effectiveness. Baits were discarded entirely at the beginning of the last outbreak which began in 1948 in favor of sprays. Chlordane and toxaphene were first used as poisons in water sprays and were followed by aldrin which was used at the rate of two ounces of actual toxicant per acre throughout the latter part of the campaign.

Methods of mixing and applying prepared baits have changed somewhat with the passing years. At first baits were mixed on a cement floor with a shovel and then broadcast by hand. During the campaign which began in 1919, a bait mixing machine known as the Manitoba Poison Bait Mixer was designed and constructed for local use. These mixers were made from prepared plans at bait mixing centers. Each machine was capable of preparing many tons of bait daily. As long as baits were used this type of machine gave greater satisfaction than any commercial machine available. It was made almost entirely from parts of old discarded machinery. Stirring rods revolved inside of a stationary drum. Additional details of this mixing machine, largely designed by Professor G. L. Shanks of The University of Manitoba are shown by Mitchener (1933).

During the 1919-1923 outbreak some farmers experimented with a machine called a hopper-dozzer which caught and killed grasshoppers in containers holding water, covered with a film of coal oil. Although many bushels of grasshoppers were caught this machine was soon discarded in favor of the more effective baits. Some ingenious individuals attempted to develop burners, endgate and trailer type bait spreaders and other pieces of equipment useful for grasshopper control, but the interest was soon lost when it became apparent that baits and hand broadcasting of baits were much more efficient.

Throughout the years when baits containing some form of arsenic were used, farm animals occasionally gained access to these prepared baits and were killed. No reports of injury to stock have been reported since sprays have been used, although still great care should be taken in storing and handling these newer poisons.

During the last decade many farmers throughout Manitoba have purchased sprayers to control weeds. These low volume sprayers, which will apply approximately five gallons of liquid per acre, were used widely during the 1948-1952 outbreak. The buffalo turbine was used to apply sprays along roadsides and other places where the common boom sprayer could not be used effectively. Spraying various crops to protect them from grasshopper injury is the modern effective method of controlling grasshoppers.

The inception of grasshopper adult and egg surveys at the time of and after egg laying has been completed each year, proved to be very useful in organizing for the control campaign the following year. This survey was first made by Norman Criddle, Federal Entomologist in Manitoba located at Treesbank and has been continued by R. D. Bird and members of his staff, Federal Entomological Laboratory, Brandon until the present time. This annual survey has enabled officers of the Manitoba Department of Agriculture and Immigration to have some idea of the amount of toxicant that will likely be required the following year and to organize the municipalities involved, well in advance of the actual outbreak. Farmers can be warned to be on the alert to observe the first damage of the season and to be ready to apply control measures before much damage has been done to the crops.

#### *Outline of Control Organization*

During the grasshopper outbreak at the turn of this century the Manitoba government supplied paris green free to those farmers who would use it in a bait and apply it where needed on their farms. It was not until the 1919-1923 campaign was under way that a Provincial organization was set up to manage the extensive operations. Wood (1933) outlined the Manitoba plan as it was in force during the 1931-1935 outbreak as follows:

"The municipality is considered the unit of organization. Each municipality is expected to appoint a campaign manager. This officer, who may or may not be a member of the council, is responsible for the general conduct of the campaign in the municipality. He is assisted by a committee in each ward, consisting of the councillor and those whom the councillor may select to act with him. After the general policy to be followed in the municipality has been decided upon, the local committees look after such details as arranging for bait distribution centres, voluntary spreading where necessary on unoccupied lands, and dealing with farmers who fail to spread bait. Establishment and general supervision of mixing stations, ordering of supplies from the Provincial Department of Agriculture, keeping of records, and checking quantity of bait going out to farmers are only a few of the many problems under the direct care of the campaign manager. Proper co-ordination of a control campaign within the municipality is possible only through a campaign manager, whose work in turn is linked up with the municipal office, through which supply orders, records, etc., are transmitted.

The province heads up the work with an officer of the Department of Agriculture, who is responsible for the general conduct of the campaign. After the policy to be followed has been decided by the Minister of Agriculture, the task of organizing the municipalities, arranging for supplies and the distribution of these, are major problems. A circular outlining policy is mailed

to each municipality. In addition, whenever possible, the municipality should be visited and the details discussed with the council, and its co-operation enlisted. Such practice will go far to ensure effective work within the municipality."

This plan was used with modifications during the 1939-1942 campaign. When sprays replaced baits in the 1948-1952 campaign the Manitoba Department of Agriculture and Immigration Publication No. 121 (February 1949) was prepared stating the duties respectively of the Manitoba Government, the Municipality and the Farmer. Where previously the Government had provided the insecticide free now the cost was shared with the municipality and the farmer according to this plan. Where farmers controlled grasshoppers on their crop land they paid for the insecticide used.

### *Predators, Parasites and Diseases of Grasshoppers*

No doubt there are many unknown factors affecting the increase and decline of grasshopper populations that are beyond our present knowledge. We do know, however, that certain predators, parasites and diseases in addition to the general weather conditions have affected grasshopper populations. Franklin's gull has been seen by the writer by the thousands in infested fields, devouring countless numbers of grasshoppers. Crows, grouse and other birds including the English sparrow feed on grasshoppers. Blister beetle larvae, the larvae of a carabid beetle, *Percosia obesa* (Say) and the larvae of the grasshopper bee fly, *Systoechus vulgaris* Loew all feed upon grasshopper eggs. A red mite (*Trombidium* sp.) occurs both on grasshoppers and in their egg pods. An egg parasite, *Scelio calopteni* Riley has been taken from grasshopper eggs in Manitoba. A fungus disease, *Empusa grylli* Fr. is, under favorable weather conditions for its development and spread, a most important control especially for *Camnula pellucida* (Scudd.). Almost entire populations of this species over widespread areas have been killed. The accelerated increase in grasshopper populations in two or three years when they reach very destructive proportions must be due to more than a lack of natural enemies. Likewise it is unlikely that the decline in population is due entirely to an increase in predatism, parasitism and disease. Abnormal precipitation may have an effect on grasshopper outbreaks.

Hargrave says, "within the period of certain knowledge the settlement (Red River) has been entirely flooded in the years 1809, 1826, 1852 and 1861 — The river is lost in one vast sea, and the sole means of communication are boats and canoes." Clark (1950) gives records of the Red River as being above flood level in the following years: 1826 (36.75'), 1852 (34.75'), 1861 (32.5'), 1950 (30.3'), 1882 (25.5'), 1904 (24.57'), 1916 (24.01'), 1948 (23.4'), 1892 (22.5'), 1897 (22.42'), 1893 (22.1'), 1923 (21.2'), 1896 (20.73'), 1945 (19.8'), 1927 (19.4'), 1898 (19.0'), 1883 (18.61'). Flood level is 18.0 feet above datum at Winnipeg. The above datum level of the Red River at the highest point for the year is shown in brackets after each year listed above.

It is impossible to measure the intensity of the grasshopper populations annually throughout the years of the recorded outbreaks. During the present century at least each outbreak began in a relatively small area, which increased in size and density of grasshopper population and then subsided during the last years of the outbreak. Beginning with 1799 we have records of the presence of grasshoppers in Manitoba in 1800, 1808, 1818, 1819, 1820, 1821, 1857, 1858, 1864, 1865, 1866, 1867, 1868, 1869, 1870, 1871, 1872, 1873, 1874, 1898, 1899, 1900, 1901, 1902, 1903, 1919, 1920, 1921, 1922, 1923, 1930, 1931, 1932, 1933, 1934, 1935, 1937, 1938, 1939, 1940, 1941, 1942, 1948, 1949, 1950, 1951 and 1952.

During the period 1799 to 1953 inclusive there have been 48 years when grasshoppers have been recorded in injurious numbers in Manitoba. During that time the Red River has been above flood level 18 seasons. There may or may not be any significance in the fact that only during four of these 18 years when the Red River has been above flood level have we had grasshoppers in injurious numbers in Manitoba and these years have occurred during this century, two of the years being 1948 and 1950. Our own observations indicate that grasshoppers thrive best under dry warm conditions.



*Observations*

That part of Manitoba situated south of the Riding Mountains and the south ends of Lake Manitoba and Lake Winnipeg has been affected most severely by grasshoppers during the past 154 years, although a few areas north of this general area have had scattered recorded outbreaks and invasions.

The incursions of grasshoppers into Manitoba before the beginning of this century were confined to the Rocky Mountain grasshopper (migratory phase), *Melanoplus mexicanus mexicanus* (Sauss.) originally *Caloptenus spretus* and later *Melanoplus spretus* Uhler. The environment was not suitable for its continued reproduction in Manitoba and elsewhere and by the beginning of this century, species of grasshoppers native to Manitoba had replaced it almost entirely as a menace to agriculture. During the five outbreaks which have taken place beginning around 1898, three species of grasshoppers, namely, *Camnula pellucida* (Scudd.), *Melanoplus mexicanus mexicanus* (Sauss.) and *Melanoplus bivittatus* (Say) have been the most widespread and injurious grasshoppers in Manitoba. They are still our most destructive species although *Melanoplus packardii* Scudd. and *Melanoplus femur-rubrum* (Deg.) have been destructive locally.

An examination of the records of grasshopper outbreaks in Manitoba during this century indicates that outbreaks have occurred at irregular intervals on the average approximately every twelve years. The records also show that it takes approximately six years from the time grasshoppers begin to increase noticeably, to reach the peak of their abundance and then to decrease until they are no longer of economic importance. This means that somewhere in Manitoba grasshoppers have been of economic importance half of the years of this century.

During an outbreak it is necessary for farmers to protect their crops by using some form of poison. Predators, parasites and disease are important over a period of years in bringing an outbreak under control but are no substitute for an active widespread control campaign.

The destruction of egg pods either in short grassed areas along roadsides, fence lines, lanes, pastures, etc. or in cultivated fields by plowing or surface cultivation is recommended. This recommendation is as good now as it was when it was first made many years ago.

Great changes have taken place during the past fifty years in the materials and methods employed in poisoning grasshoppers. The use of a relatively small amount of toxicant in a water spray on the growing food plants of grasshoppers is presently very successfully employed for their control.

More attention should be given to control in the build up years of each outbreak. If sprays were applied to areas where populations are building up before they are of much economic importance it is possible that the severity of an outbreak could be minimized. This would involve alerting the farmers concerned and emphasizing the need of timely poisoning. Sprays containing an insecticide mixed with the herbicide used to kill farm weeds might be used effectively.

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## SUMMARY OF STUDIES ON NEW ACARICIDES IN CANADA, 1948-1953<sup>1</sup>

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This report on some of the new acaricides used for the control of the two-spotted spider mite, *Tetranychus bimaculatus* Harvey, the European red mite, *Metatetranychus ulmi* (Koch), and related species on fruit crops in Canada is based partly on laboratory investigations by the author,

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reported in more detail elsewhere (3), and partly on orchard trials at the various laboratories of the Fruit Insect Unit of the Entomology Division. It is a continuation of the reports on acaricide investigations commenced in 1946 (1, 6) and deals with materials introduced from 1948 to 1953 by various insecticide manufacturers.

In the residual tests on each material, a number of uninfested bean plants were sprayed at one time, and at intervals over a period of at least 14 days two-spotted spider mites were introduced on a succession of these plants by placing pieces of heavily infested leaves upon them, two plants being used in each test. After 24 hours the active mites had moved to the plants and the pieces of leaves were removed. Mortality records were taken seven, 14, and sometimes 21 days after the introduction of the mites on the sprayed foliage, by counting living and dead mites under a binocular microscope. All mortality records included not only the introduced mites but also those hatching from eggs deposited on the sprayed foliage (2).

The following spray materials and amounts per 100 gal. were used in the compatibility tests: DDT, 50 per cent wettable powder, 2 lb.; lead arsenate, 4 lb.; Dilan, 25 per cent solution, 1.33 pt.; methoxychlor, 50 per cent wettable powder, 3 lb.; nicotine sulphate, 40 per cent, 1 pt.; ferbam, 76 per cent wettable powder, 2 lb.; wettable sulphur, 10 lb.; phenyl mercury acetate (HL-331), 0.5 pt.; Phygon XL, 55.5 per cent wettable powder, 1 lb.; glyoxalidine (Crag 341-SC), 3 pt.; Coposil, 2.5 lb.; Cupro-K, 4 lb.; COCS, 4 lb.; captan, 50 per cent wettable powder, 2 lb.; bordeaux mixture, 5-5-100; hydrated lime, 10 lb.; lime-sulphur, 2 gal.

Some of the acaricides have been thoroughly tested under field conditions, and have been used with satisfactory results by fruit growers. Many others are still in the experimental stage and are not registered for commercial use in Canada.

#### PARA-CHLOROPHENYL P-CHLOROBENZENESULPHONATE

(C-854, Ovotran)

Ovotran is a very effective acaricide with prolonged residual ovicidal toxicity. Many mature mites survived sprays of this material, but most immature forms, including eggs, were destroyed. The surviving adults continued to deposit eggs in large numbers on the sprayed foliage, but these eggs failed to hatch over an extended period.

Experimental trials and grower use have shown it to be one of the most effective materials to control the European red mite on apple in Ontario, Nova Scotia, Quebec, and British Columbia, and on peach and plum in Ontario. In Manitoba one application on raspberry before flowering gave excellent control of the Pacific mite, *Eotetranychus pacificus* (McG.), without damage to the foliage.

No foliage injury to apple, peach, or plum due to sprays of Ovotran has been observed in Ontario, but some injury to apple foliage resulted in British Columbia and Nova Scotia.

Ovotran appeared to be compatible with all the commonly used spray materials.

#### 2,4-DICHLOROPHENYL BENZENESULPHONATE

(Miticide 923, Genitol)

A 50 per cent emulsifiable solution of Miticide 923 gave nearly 100 per cent mortality of active stages of the two-spotted spider mite at dilutions up to 1-1600. Similar high mortalities of the European red mite on peach were recorded in laboratory experiments. The ovicidal action against the two-spotted spider mite was good when Miticide 923 was used at 1-400 or stronger, but at 1-800 less than half of the sprayed eggs were destroyed. The residual action was comparatively poor. Although a large number of immature mites were killed by residues up to 10 days old, mature females survived to deposit large numbers of eggs; these hatched, and many of the mites were active on plants examined two weeks after being infested.

It is compatible with all the common insecticides and fungicides.



In orchard trials in British Columbia, Quebec, and Nova Scotia it gave good results against the European red mite on apple, but caused some foliage injury to apples in Nova Scotia and British Columbia. In Ontario, it adequately controlled the European red mite on apple when two applications of a 1-800 spray were applied on July 7 and 17.

The manufacturer has not registered it in Canada.

#### PARA-CHLOROPHENYL PHENYL SULPHONE

(R-242, Sulphenone)

Greenhouse tests indicated this chemical to be a very promising acaricide, especially against the two-spotted spider mite. Against the European red mite it was somewhat less effective. High mortalities of active forms of the two-spotted spider mite were recorded when they were sprayed with as little as 0.125 lb. of the active ingredient per 100 gal. The ovicidal toxicity was good; 89 to 99 per cent of the eggs were destroyed when sprayed with 1 to 4 lb. of the 50 per cent powder per 100 gal. The residual toxicity was of long duration, being in the same category as that of Ovotran. Mite populations introduced to sprayed foliage 14 days after spraying were destroyed to the extent of 90.3 per cent.

This acaricide is compatible with all the commonly used insecticides and fungicides.

In Ontario 1 lb. of 50 per cent R-242 in each of four cover sprays on apple gave good control of the European red mite; and in British Columbia, apple orchard trials gave promising results against the European red mite, the two-spotted spider mite, and the yellow spider mite, *Eotetranychus carpini borealis* (Ewing). There was no fruit or foliage injury to apple or plum in Ontario orchard trials.

Sulphenone has been recommended for the control of the clover mite, the European red mite, and rust mites in British Columbia since 1952.

#### BETA-CHLOROETHYL-BETA-(P-TERTIARY BUTYLPHENOXY)-ALPHA METHYL-ETHYLSULPHITE

(Miticide 88R, Aramite)

In greenhouse experiments, Aramite, 15 per cent spray powder, gave excellent mortalities of both the two-spotted spider mite and the European red mite. When the powder was used at 0.25 to 2.0 lb. per 100 gal., mite mortalities, two weeks after application ranged from 93.3 to 100 per cent.

This acaricide has poor ovicidal toxicity, destroying only 82.9 per cent of sprayed eggs at approximately 5 times the recommended dosage; at the recommended rate of 1.25 lb. of 15 per cent powder per 100 gal., the egg mortality was 12.1 per cent. However, the residual action destroyed practically all mites hatching within a week after the application of the spray.

Aramite may be combined with most of the commonly used spray materials except hydrated lime and bordeaux mixture. Under greenhouse conditions it caused no foliage injury to bean or peach.

In British Columbia it has given satisfactory control in apple orchards against the Pacific mite and the yellow spider mite, but only fair control of the European red mite. In two years' orchard trials in Ontario it controlled the European red mite on apple and peach, and the two-spotted spider mite on peach.

Aramite has been registered for sale in Canada for some time, and its acaricidal value has been recognized by fruit growers in all parts of the country.

## ETHOXYMETHYL-DI- (P-CHLOROPHENYL)-CARBINOL

(Miticide 337)

Ethoxymethyl-di- (p-chlorophenyl)-carbinol had good acaricidal action against the two-spotted spider mite, but was not as effective as its close relative 4,4-dichlorobenzilicacid ethyl ester (Miticide 338). Excellent mortalities of active forms were recorded when the 25 per cent emulsion of Miticide 337 was used at 0.5 to 4 pt. per 100 gal. The residual toxicity to active forms was low at 1 pt. or less..

High percentages of the eggs were destroyed when sprayed with 4 pt. per 100 gal.; at 2 pt. and 1 pt. the egg mortalities were reduced to 65.1 and 20.7 per cent respectively. Lower rates were of no value.

A residue left by 2 pt. per 100 gal. on bean foliage gave high mortalities of active forms for 3 days, and erratic mortalities from the fourth to the seventh day after spraying. Beyond this point the toxicity of the residue was low.

Miticide 337 was compatible with all the common insecticides and fungicides tested, although methoxychlor sprays delayed the acaricidal action slightly.

One year's trials against the European red mite on apple in Ontario indicated that Miticide 337 at 0.5 pt. of 25 per cent emulsion per 100 gal. in 4 cover sprays was satisfactory. Two application at 1 pt. on plums also gave good control and no foliage injury.

This material has not been registered in Canada.

## 4,4-DICHLOROBENZILICACID ETHYL ESTHER

(Miticide 338, Chlorobenzilate)

The 25 per cent emulsion of 4,4-dichlorobenzilicacid ethyl ester, at 0.125 pt. or more per 100 gal., destroyed practically 100 per cent of active forms, and at 0.5 pt. or more eliminated mite populations 14 days after spraying. In residual action it ranked with the best of all acaricides tested. For 14 days after spraying, residues of a spray containing 1 pt. of the 25 per cent emulsion per 100 gal. continued to destroy very high percentages of the active stages of the two-spotted spider mite, and a 3-week-old residue killed 61.8 per cent of the mites. One pint per 100 gal. destroyed close to 100 per cent of the eggs; 0.5 pt., 55 per cent.

Acaricide 338 did not lose its effectiveness when combined with any of the common insecticides and fungicides. When it was combined with 10 lb. of hydrated lime per 100 gal. the mortality of mites was slightly delayed, but not to such an extent as to affect the residual toxicity.

In orchard tests on apple and plum in Ontario, it gave very good control of the European red mite. However, two applications of 1 pt. of the 25 per cent emulsion per 100 gal. plus lead arsenate and sulphur on plums caused light to very severe foliage injury, depending on the variety, and resulted in some instances in heavy loss of leaves. There was a slight amount of leaf injury on Delicious apple.

It has not been registered in Canada.

## BUTOXPOLYPROPYLENE GLYCOL

(Miticide 7)

Butoxypolypropylene glycol, 95 per cent solution, had good acaricidal action against active forms of the two-spotted spider mite at 1-200 to 1-800. High rates also destroyed high percentages of eggs, but at 1-800 the ovicidal toxicity was reduced to 41.7 per cent. The residual action was outstanding; 25 days after spraying, over 80 per cent of a mite population was destroyed, and newly hatched mites from eggs deposited on the sprayed foliage were succumbing in large numbers. Miticide 7 has a comparatively slow action.

This material was compatible with most of the commonly used insecticides and fungicides except hydrated lime and bordeaux mixture, which reduced the lethal action to a considerable extent.

Water sprayed on residues of Miticide 7 reduced the killing action, including ovicidal toxicity, to a considerable degree. For instance, a 1-400 spray destroyed a mite population when the residue remained dry, but when syringed with water for 1 min. at 6 hours after spraying, the mortality was reduced to 69 per cent. Similarly, egg mortalities from a 1-200 spray were reduced from 100 to 59.6 per cent when water was sprayed over the residues. This suggests uncertain results under orchard conditions.

In Ontario the European red mite was fairly well controlled in the orchard with 15 fl. oz. per 100 gal. of Miticide 7, used in 4 successive cover sprays on apple. However, noticeable leaf scorch developed after the second application and this injury increased after subsequent sprays.

It has not been registered for sale in Canada.

### ILLOXOL

Illoxol (60% polychloreandomethylenetetrahydrindene) has both insecticidal and acaricidal properties, which are not commonly found together in chlorinated hydrocarbons. It destroyed aphids, the pear psylla, *Psylla pyricola* Foerst., and the plum curculio, *Conotrachelus nenuphar* (Hbst.), and at comparatively strong dosages was a satisfactory acaricide. At dilutions of 1-400 of a 60 per cent emulsion the initial toxicity to active forms of the two-spotted spider mite, and the residual toxicity to newly hatched mites, were high. The ovicidal action was not pronounced, and the residual toxicity to the two-spotted spider mite beyond the larval stage was poor.

Illoxol was compatible with all the commonly used spray materials tested except glyoxalidine.

Orchard tests with it in 1953 against a number of pests had to be abandoned when injury to peach, plum, and pear occurred. Two applications of a spray of sulphur and Illoxol on peach caused severe leaf injury and heavy defoliation; the fruit of several varieties of plums also was injured by this combination. The fruit injury was a characteristic russetting severe enough to spoil the appearance.

This material is still in the experimental stage, and has not been registered for sale in Canada.

### 2-HEPTADECYLGLYOXALIDINE ACETATE

(Glyodin, Crag 341SC, Crag Fruit Fungicide)

Glyoxalidine, which is primarily a fungicide, had some acaricidal action. At the recommended rate of 3 pt. of the 34 per cent solution per 100 gal., 86 per cent of a two-spotted spider mite population was destroyed. In combination with the small quantity of hydrated lime recommended by the manufacturer, its acaricidal action was reduced considerably.

This spray material has no ovicidal or residual toxicity to mites. However, in greenhouse experiments three applications at 10-day intervals gave adequate control of a two-spotted spider mite infestation.

In orchard tests in both Ontario and Nova Scotia, Crag Fruit Fungicide without lime held the European red mite under control, but with lime added the mite populations throughout the season were only slightly lower than those on the check trees.

### DINITRO CAPRYLPHENYL CROTONATE

(Arathane, Karathane, Mildex, Iscothan)

At 1 lb. or more of the 25 per cent spray powder per 100 gal., Arathane destroyed from 84.7 to 100 per cent of active forms of the two-spotted spider mite; at 0.5 lb. it killed 97.7 per cent of the European red mite. It has very good residual toxicity, and some, but not pronounced,



ovicidal action. It acts slowly. A spray of 1 lb. of 25 per cent powder per 100 gal. destroyed 57.6 per cent of active two-spotted spider mites after 3 days, and 86.3 per cent after 7 days.

Arathane was compatible with most of the comon spray materials except bordeaux mixture and hydrated lime.

In apple orchard tests in Ontario, Arathane in two sprays applied on June 22 and July 5 gave fair immediate reduction in population of the European red mite with a rapid build-up during August. Variable results from it, some of them not satisfactory, were reported from orchard tests in British Columbia and Nova Scotia.

Slight injury in the form of small brown spotting occurred on plum foliage when Arathane was applied at 1 or 2 lb. of 25 per cent powder per 100 gal. Cherry seedlings and bean foliage were uninjured by this acaricide.

#### ETHYL P-NITROPHENYL THIONOBENZENE PHOSPHONATE

##### (EPN)

In greenhouse experiments very small amounts of EPN gave high mortalities of the two-spotted spider mite; 1 oz. of the 31.5 per cent powder per 100 gal. destroyed all mites on plants sprayed two weeks before examination. The powerful residual action destroyed mites that hatched from eggs present on the plants when sprayed. EPN was not a good ovicide; 1 lb. of the powder per 100 gal. killed 65.6 per cent of the eggs, and at weaker concentrations the mortalities were negligible.

Few experimental acaricides so far tested possessed such longlasting residual toxicity. Mortality of mites introduced 12 days after the foliage was sprayed with 0.25 lb. of the 31.5 per cent powder per 100 gal. was almost 100 per cent; at 14 days, 80 per cent; and at 20 days, 70 per cent.

When combined with bordeaux mixture or hydrated lime, the acaricidal action of EPN was almost completely destroyed. It was compatible with all other spray materials tested except possibly methoxychlor.

Orchard tests with EPN have generally given very good results against various species of mites. In Ontario, 0.5 or 1 lb. of 27 per cent powder per 100 gal. in two applications on plum held the European red mite to insignificant numbers throughout the season, and on apple two summer applications of 0.5 lb. per 100 gal. was the best acaricide program out of nine tested in 1950. EPN at 0.75 lb. per 100 gal. in 5 applications on Elberta peaches in an experiment for the control of the oriental fruit moth, *Grapholitha molesta* (Busck), gave almost 100 per cent mortality of the European red mite, but poor control of the two-spotted spider mite that moved to the trees from the cover crop of weeds late in the season.

EPN controlled the European red mite and the yellow spider mite, but was less effective against the two-spotted spider mite and the Pacific mite in British Columbia. In Nova Scotia and Quebec excellent protection against the European red mite attacking apple was secured.

Apple foliage injury, sometimes severe, occurred chiefly on McIntosh or McIntosh strains in Nova Scotia, British Columbia, and southwestern Ontario when a 27 per cent wettable powder at 0.5 to 1 lb. per 100 gal. was applied at the pink stage of development. No foliage injury developed in the Niagara peninsula of Ontario on apple, pear, plum, or peach. However, in the Niagara experiments, apple sprays of EPN were applied in the second and third cover sprays approximately 5 weeks later than the pink stage.

Besides its very satisfactory acaricidal action, this phosphorus compound has insecticidal properties of value, controlling such important pests as the pear psylla, aphids, the plum curculio, and the oriental fruit moth.

## METACIDE

(Gearphos)

Metacide, a 33.3 per cent solution of the methyl analogue of parathion and related compounds, at dilutions up to 1-2000 destroyed over 90 per cent of active forms of the two-spotted spider mite, and dilutions of 1-4000 and 1-8000 killed 86.8 and 70.6 per cent respectively. The residual and ovicidal toxicities were poor. Mite populations examined two weeks after spraying with a 1-500 dilution showed 77.4 per cent mortality; with 1-1000, 56.5 per cent. At all dilutions some of the mites that hatched from eggs present when the sprays were applied survived.

Metacide is compatible with other spray materials in so far as the immediate mortality is concerned.

In Ontario, 6 fl. oz. per 100 gal. in each of four cover sprays controlled the European red mite on apple, and 15 oz. per 100 gal. in two applications 10 days apart controlled the same species on prunes. In Quebec, one summer application at 1 pt. per 100 gal. gave control of the European red mite on apple for one month.

Metacide at 15 oz. per 100 gal. was responsible for some foliage injury on pear. This injury was of minor importance, but was more conspicuous than that caused by parathion in neighbouring plots. No foliage injury occurred on apple.

## DIETHYL-METHYLCOUMARINYL THIOPHOSPHATE

(Potasan, Miticide E-838)

Tests in the greenhouse indicated that Miticide E-838 had about the same value as parathion as an acaricide, with probably a better residual toxicity. A 60 per cent solution diluted to 1-1000 destroyed close to 100 per cent of active populations of the two-spotted spider mite, and retained good residual toxicity after 14 days. The ovicidal action was poor, but newly hatched mites were destroyed rapidly by the spray residues.

The immediate toxicity was reduced to some extent when Miticide E-838 was used with lead arsenate, methoxychlor, bordeaux mixture, sulphur, or hydrated lime. It was compatible with other commonly used spray materials tested. The residual action was greatly reduced in the presence of bordeaux mixture or hydrated lime.

No foliage injury occurred on bean.

## S-(1,2-DICARBOETHOXYETHYL)O,O-DIMETHYL DITHIOPHOSPHATE

(Malathion, Malathon, 4049)

Very high mortalities of the two-spotted spider mite resulted when malathion was used at 1 lb. of the 25 per cent powder per 100 gal. At rates lower than 0.5 lb. the lethal action was reduced considerably. Against the European red mite in insectary tests high mortalities were given by 2 lb. of the powder per 100 gal., fair mortalities by 0.25 to 1 lb., practically none by 0.125 lb.

The ovicidal action was poor, most of the eggs hatching when sprayed with 4 lb. of 25 per cent powder per 100 gal.

In residual action tests under greenhouse conditions, malathion gave high mortalities for approximately 10 days after application. A 14-day residue destroyed over 50 per cent of a mite population. Up to the fourth day mature mites were killed rapidly, laying very few eggs before succumbing.

Hydrated lime and bordeaux mixture were incompatible with malathion. All other commonly used spray materials tested had no effect on its toxicity.

In Ontario, four applications of 25 per cent malathion powder at 1 lb. per 100 gal., applied in successive cover sprays on apple, gave fairly satisfactory control of the European red mite, but were not as effective as four sprays of 15 per cent parathion powder at 0.5 lb. On prunes, two sprays of 2 lb. per 100 gal. at the shuck stage and 10 days later kept the European red mite down to insignificant numbers for the whole season.

No foliage or fruit injury from malathion has occurred on peach, plum, pear, or apple in the Niagara peninsula.

#### O,O-DIMETHYL O,3-CHLORO-4-NITROPHENYL THIOPHOSPHATE

(Chlorthion, 22/190)

Chlorthion, an excellent aphicide, was only a fair acaricide. A 50 per cent emulsion at the high rate of 2 pt. per 100 gal., killed 91.4 per cent of the two-spotted spider mite, and the residual mortality after 14 days was 68.7 per cent. Weaker dosages gave much poorer results. The ovicidal toxicity was of little value; a spray containing 4 pt. per 100 gal. destroyed only 13.5 per cent of the eggs of the two-spotted spider mite.

#### DIETHOXY THIOPHOSPHORIC AZIDE

(E-1550)

A 50 per cent emulsion of diethoxy thiophosphoric azide killed from 90.3 to 100 per cent of active forms of the two-spotted spider mite at dilutions of 1-3200 to 1-200. Eggs were not destroyed, and almost all mites hatching from them on sprayed foliage survived. There was little, if any, residual toxicity.

This acaricide appeared to be compatible with all the commonly used spray materials. Hydrated lime and lead arsenate reduced the toxicity to some extent, but bordeaux mixture had no effect.

Bean foliage was not injured by E-1550 sprays.

#### N,N-DIETHYLTHIOCARBAMYL-O,O-DIISOPROPYL DITHIOPHOSPHATE

(Compound 326)

This phosphate chemical, when tested in the greenhouse against the two-spotted spider mite, was in the same category as parathion as an acaricide. A 25 per cent spray powder at 0.125 lb. or more per 100 gal. destroyed 90.3 to 100 per cent of active forms. Its residual toxicity lasted sufficiently long to eliminate a mite population sprayed with 0.5 lb. per 100 gal. Its ovicidal toxicity was satisfactory only at a dosage of at least 2 lb. per 100 gal.

The residual action was good for 3 days after spraying under greenhouse conditions. Some mites were destroyed for 14 days; but after the second day, eggs laid by surviving females hatched and a substantial percentage of the new mites survived on the sprayed foliage.

The immediate toxicity of Compound 326 was not affected by any of the commonly used spray materials except hydrated lime, but the residual action was materially reduced by lime-sulphur, bordeaux mixture, or hydrated lime.

In Ontario, the European red mite was satisfactorily controlled on plums when sprayed with Compound 326 at 2 lb. of the 25 per cent powder per 100 gal. at the shuck stage and 10 days later.

#### BIS (DIMETHYLAMINO) PHOSPHONOUS ANHYDRIDE

(Schradan)

A 45 per cent emulsion of schradan was very effective against greenhouse populations of the two-spotted spider mite at dilutions up to 1-8000 applied as foliage sprays. Against the European



red mite on peach seedlings it was not quite as effective and did not give high mortalities at dilutions greater than 1-3200.

The residual action was long-lasting and effective. Almost 100 per cent of two-spotted spider mites were destroyed when placed on bean foliage sprayed up to 21 days previously with 45 per cent schradan, 1-800, and 64 per cent when placed on foliage sprayed 39 days previously.

When combined with hydrated lime, schradan gave poor mortality of mites at the time of spraying; bordeaux mixture, Dilan, and methoxychlor reduced the lethal action to a lesser extent. Schradan was compatible with DDT, lead arsenate, ferbam, sulphur, glyoxalidine, and captan.

As there has been some reluctance to use systemic poisons on fruit, very little orchard experimental work has been done on them. In British Columbia, applications of 2 or 4 pt. of 45 per cent schradan per 100 gal. to apple trees gave excellent control of the European red mite for 1 and 2 months respectively. In a further test, control of the clover mite throughout the season resulted when apples were sprayed at the pink stage with 2 pt. per 100 gal. At 1 pt. per 100 gal. in a summer spray (June 28), schradan failed to give control of the clover mite.

No foliage injury occurred on bean, pear, plum, or peach in Ontario, but slight injury to Newton apple leaves was reported in British Columbia.

#### ETHYL MERCAPTOETHYL DIETHYL THIOPHOSPHATE

(Demeton, 8173, Systox)

A 70 per cent solution of the systemic insecticide demeton at dilutions as great as 1-64,000 applied as foliage sprays, satisfactorily controlled both the European red mite and the two-spotted spider mite in the greenhouse. Even at 1-128,000, mortalities were remarkably high. Sprays of 1-1000 destroyed most of the eggs, but weaker sprays had little ovicidal toxicity.

When active stages of mites were placed on foliage sprayed with 70 per cent demeton at 1-800, the residues continued to destroy them for 41 days, the duration of the experiment.

When combined with the commonly used insecticides and fungicides, this acaricide remained effective against the two-spotted spider mite.

In Ontario orchard trials, a 50 per cent emulsion of demeton, at 1 pt. per 100 gal. in two applications on June 11 and June 19, gave excellent control of the European red mite on apple. The population was held to approximately 0.15 to 0.2 mites per leaf for almost 2 months after the last application, whereas on the check trees there were 15.8 to 75.0 mites per leaf during the same period. In British Columbia, 0.25 pt. of 50 per cent demeton per 100 gal. controlled the clover mite, the two-spotted spider mite, and the Pacific mite very satisfactorily for long periods in apple orchard tests.

#### ETHYL SELENOETHYL DIETHYL THIOPHOSPHATE

(8172)

The systemic chemical ethyl selenoethyl diethyl thiophosphate was even more effective as an acaricide than demeton. Dilutions of the 70 per cent emulsion at 1-2000 destroyed two-spotted spider mite eggs, and high percentages of active mites were destroyed by dilutions as great as 1-128,000.

The residual toxicity of a 1-2000 spray of 8172 was pronounced, the residues giving 100 per cent mortality for at least 17 days, the duration of the experiment.

This acaricide was compatible with all the commonly used spray materials except hydrated lime which reduced the mortality.

No orchard experiments have been attempted with this systemic material.

## SUMMARY

Notes are presented on the effectiveness of 20 new acaricides against the two-spotted spider mite and other mites attacking fruit trees, on the basis of greenhouse experiments in Ontario and orchard investigations in Nova Scotia, Quebec, Ontario, and British Columbia.

Para-chlorophenyl p-chlorobenzenesulphonate had powerful ovicidal action with a residual toxicity for a long period. Para-chlorophenyl phenyl sulphone destroyed active mite forms and eggs but did not have residual ovicidal action for so long. Beta-chloroethyl-beta-(p-tertiary butylphenoxy)-alpha-methyl-ethylsulphite had poor ovicidal toxicity but killed active forms satisfactorily for at least a week after the spray application. These three important acaricides have already found a place in orchard control programs after a few years of testing in the greenhouse and the orchard.

Ethoxymethyl-di-(p-chlorophenyl)-carbinol and its close relative 4,4-dichlorobenzilic acid ethyl ester had good acaricidal properties. The latter was the better acaricide in greenhouse trials against the two-spotted spider mite, having a longer residual toxicity and a more pronounced ovicidal action. However, 4,4-dichlorobenzilic acid ethyl ester sprays were phytotoxic in some orchard trials.

Butoxypolypropylene glycol showed considerable promise, but foliage residues washed away, reducing mite mortalities greatly. Illoxol, a chlorinated hydrocarbon, possessed both insecticidal and acaricidal properties. Its acaricidal action was not so good as those of several other chemicals tested. Glyoxalidine, primarily a fungicide, destroyed fairly high percentages of active mite forms, but had no ovicidal or residual toxicity. Dinitro caprylphenyl crotonate gave variable results, and produced some foliage injury.

The outstanding acaricides among the phosphorus compounds tested were ethyl-p-nitrophenyl thionobenzene phosphonate (EPN) and S-(1,2-dicarboethoxyethyl)0,0-dimethyl dithiophosphate, both of which gave good results in orchard trials. EPN gave very good control of several species of mites and owing to its prolonged residual toxicity was superior to parathion as an acaricide. N,N-diethylthiocarbamyl-0,0-diisopropyl dithiophosphate showed considerable promise in the greenhouse trials, but further field work with it is required. It did not have the long-lasting residual action of some of the other phosphate acaricides.

The systemic phosphorus chemicals were outstanding, especially from the standpoint of residual toxicity, in which respect demeton was superior to schradan.

Several other chemicals with acaricidal properties were tested, some of which, after further orchard trials, may prove valuable.

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## THE EUROPEAN CORN BORER, *PYRAUSTA NUBILALIS* (HBN.) (LEPIDOPTERA: PYRALIDIDAE), IN CANADA: A REVIEW<sup>1</sup>

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Since it was first found in Canada in 1920, the European corn borer, *Pyrausta nubilalis* (Hbn.), has spread widely and fairly rapidly. In 1953, it was found in all provinces except Newfoundland, Alberta, and British Columbia. The most recent paper on the borer in Canada was that by Keenan (10) in 1927. There have been notable changes in the status of the borer since that date.

The writer visited the corn-growing areas in Manitoba, southern Saskatchewan, and the Taber-Lethbridge district of Alberta in 1952, and those in Quebec and the Maritime Provinces in 1953. This paper reviews the history of the borer in Canada and its present status.

### HISTORY OF THE INSECT

*Ontario.*—The European corn borer was first reported in Canada near Welland, Ontario, on August 10, 1920 (11). However, the borer was known to corn growers in the St. Thomas—Port Stanley area as early as 1910 (9). From 1920 to 1930, the borer spread rapidly throughout the corn-growing areas of Ontario. The intensity of infestation was greatest in the counties of Essex and Kent, where from 70 to 80 per cent of the Canadian grain corn is grown. So severe was the infestation in this region that farmers seriously considered growing other crops instead of corn, but a combination of circumstances arose that made so extreme a measure unnecessary.

In Ontario, the Corn Borer Act of 1927 was passed in an attempt to check the growing menace of this pest (4). This required farmers in areas where the Act was in force to suitably dispose of corn stubble in the spring, thus destroying borers which had overwintered. For several years after the Act was passed, it was thought that this measure greatly reduced the borer population. In retrospect, it is evident that this means of control was over-rated. It is true that infestation in Ontario was reduced after the introduction of the Act, but other factors appear to be responsible.

The principal factor in the reduction of the borer population in the early 1930's was the weather. Stirrett (16) showed that high temperatures and low precipitation during June and July were associated with low infestation by the borer. This was especially true in 1934, when the infestation by the borer was the lowest ever recorded (3). Writing about conditions in the neighbouring state of Indiana, Davis (5) stated that the season of 1934 definitely set back the borer several years, at least in the drought areas of the central west.

Beginning about 1938, larger acreages of hybrid corn were planted in the province. This undoubtedly helped reduce the borer infestation, although it is difficult to estimate to what degree. It is known that the sturdiness of the plant increases the degree of tolerance after the borer gains entry (17). In a year of severe infestation such as 1949, hybrid corn was sturdy enough to carry a high borer population with little stalk breakage.

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The multivoltine strain of the borer has increased greatly in Ontario since 1940, causing important changes in the borer situation (19). Stalk damage is caused mainly by the first generation. Under favourable conditions, second-generation borers may cause serious damage to the ears by feeding on the kernels and by boring into the shank, causing ear drop. In a year of severe infestation, the latter type of damage could be important in the grain corn district. Generally, however, canning corn is mainly affected by second-generation borers. Frequently, field-grown peppers are also infested by the second generation.

In recent years, sweet corn acreage has increased considerably. Formerly, the growing of this crop was hazardous because of the constant threat of borer damage. The use of insecticides, such as DDT and ryania, has reduced this threat appreciably.

*Quebec.*—The history of the borer in Quebec is similar to that in Ontario except that corn is not so important a crop nor, in general, has the infestation been as severe. According to Keenan (10), the borer was first found in Quebec in 1926, in several widely scattered places. This was the single-generation strain. In 1953, there was evidence of a partial second generation in the area south of Montreal. The borer is regarded as a serious pest of sweet and canning corn in this province.

*Maritime Provinces.*—Gorham *et al.* (7) reported that the borer was first found in the Maritimes in the St. John valley in 1928. Infestation seems to have been very light and scattered, and from 1931 to 1944 it was not recorded in New Brunswick (18). In 1945, the borer again appeared in that province. Gorham (8) stated that "a light but widely scattered infestation was found in New Brunswick, the result probably of a flight of the adult moths from New England." The borer seems to have become established then, since it is now regarded as a permanent pest by sweet corn growers in the St. John-Grand Lake region. The fields, although of small acreage, are widely distributed and are an important source of revenue to the farmers. Consequently, the presence of the borer is viewed with concern.

In Nova Scotia, the borer first appeared in 1929 in widely scattered parts of the province (6). This apparently was the two-generation strain, although only a single generation was present in 1953. The insect is now regarded as a serious pest in the Annapolis Valley.

Two larvae found in 1949 constitute the only known record for Prince Edward Island (2).

*Western Canada.*—The borer was recorded for the first time in both Saskatchewan and Manitoba in 1949 (12), presumably arriving there by way of the adjacent states of Minnesota and North Dakota (14). In Saskatchewan, the infestations were first found in the semi-arid prairie area around Estevan; sweet corn is grown only in backyard gardens, but it constitutes an important food item. According to Stewart and Putnam (15), the borer was found in the Saskatoon area in 1953. In Manitoba, Smith (14) stated that the borer was first found on the experimental plots at the Morden Experimental Station on August 4, 1949.

#### PRESENT STATUS OF THE BORER

So far as Ontario and Quebec are concerned, the borer remains a pest of prime importance. It seems improbable, however, that outbreaks will again arise comparable with those of 1926 and 1927. The use of hybrid varieties and insecticides reduces damage in grain corn, even in an outbreak year. Insecticides, if correctly applied, check the borer in sweet corn, and there has been no evidence of development of strains resistant to insecticides.

In the Maritime Provinces, the borer is more important than formerly. The sweet corn acreage has been increased, and in the Wolfville-Kentville area the growing of sweet corn has become an important industry. The product is graded, pre-chilled, and packaged for shipment. This corn is of a superior type and must be borer-free. The methods of combatting this insect are not as well organized as in Ontario and Quebec, but there is no reason to suppose that these methods will not be improved.

The borer is a new pest in Western Canada and corn acreages are smaller than in the east. In Manitoba, however, a considerable acreage of field corn, sweet corn, and canning corn is grown. Here the borer has caused considerable damage, and it is regarded as a pest of increasing importance. It has been found at several widely scattered points in Saskatchewan, but it is too early to state to what degree it will affect the agricultural economy. It appears that this insect readily survives the cold temperatures and semi-arid conditions of the southern prairie region; in Russia the borer is found under similar conditions at a more northern latitude than in Canada (1).

There is no evidence of the borer in Alberta. It has, however, spread well across the Great Plains, in the United States, being present in both Montana and Wyoming (13). It will probably be only a matter of time before it reaches the irrigated areas of southern Alberta. Canning corn is grown in considerable acreage on irrigated land in the Taber-Lethbridge district. The manner of growing the corn is such that infestation could very quickly spread in a particular field where the microclimate has high temperature and high humidity. Cool nights, however, may help to reduce moth flight should the borer reach Alberta.

### SUMMARY

The European corn borer, which has been a serious pest of corn in Ontario and Quebec for over 30 years, is now found in Canada from the Maritime Provinces to south-central Saskatchewan. The shelled corn industry does not suffer to the same extent as formerly, partly because of the development of hybrid corn and partly because of the increase of the second generation of the borer. New methods of agriculture in Nova Scotia and Manitoba have increased the importance of this insect in those provinces. In southern Alberta, choice canning corn is grown on irrigated land; so far the borer has not been found in that province, but it is present in the eastern part of the neighbouring state of Montana. The borer remains an important pest in sweet corn in Eastern Canada, but means of control are better and more readily available than formerly.

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PARASITISM OF TWIG-INFESTING LARVAE OF THE ORIENTAL  
FRUIT MOTH, *GRAPHOLITHA MOLESTA* (BUSCK)  
(LEPIDOPTERA : OLETHREUTIDAE),  
IN ONTARIO, 1939 — 1953<sup>1</sup>

H. R. BOYCE<sup>2</sup> and G. G. DUSTAN<sup>3</sup>

This paper is primarily a comparison of parasitism of twig-infesting larvae of the oriental fruit moth, *Grapholitha molesta* (Busck), in young peach orchards in Essex County and in the Niagara Peninsula, before and after DDT and parathion came into use for control of the moth and several other pests of peach. Data on parasitism for the years 1939 to 1946 were published by Boyce (1) in 1947, and are included with those obtained for the years 1947 to 1953.

The peach-growing areas of Essex County and the Niagara Peninsula are approximately two hundred miles apart. In the intervening area few peaches are grown.

TRENDS IN USE OF INSECTICIDES IN PEACH ORCHARDS

During 1929 to 1945, reliance was placed on weather conditions, native species of natural enemies, and the introduced parasite *Macrocentrus ancylivorus* Rohw. to control the oriental fruit moth. After a severe infestation in 1945, and experimental work with DDT as reported by Dustan *et al.* (2), DDT was introduced in 1946 in some commercial orchards of the Niagara Peninsula (Lincoln and Welland counties) to aid in the control of the moth. In Essex County, however, DDT sprays were not applied until 1948. The use of DDT in peach orchards has become general in both areas.

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The DDT spray program usually followed has consisted of two sprays in early July and one in August. In the Niagara Peninsula these are applied to bearing peach trees; they are usually not applied to the two- to five-year-old trees, from which collections were made in the present study. A few growers, particularly in the Vineland area, spray both young and old peach trees with the three regular sprays of DDT. In addition they make two applications of either DDT or parathion in late May and early June. In Essex County, however, most growers apply the three regular sprays of DDT to trees of both age groups.

Some growers in the Niagara Peninsula began to use parathion in 1949 for the control of mites. In this area spraying with this material increased in subsequent years following recommendations that it be used for the control of the cottony peach scale, mites, and the oriental fruit moth during July, and of the plum curculio during late May and early June. Meanwhile the recommended rates of application were increased gradually from three-quarters of a pound of 15 per cent parathion in 1949 to one and one-half pounds in 1953.

In Essex County, however, growers used parathion only to a very limited extent in a few orchards. Thus a considerable difference has occurred between the Essex County and Niagara Peninsula areas in the usage of two insecticides that might influence population levels of the several species of larval parasites of the oriental fruit moth.

#### METHODS

Though the oriental fruit moth has three generations and sometimes a partial fourth each year in Ontario, surveys of parasitism were limited to twig-infesting larvae of the first two generations. The difficulty of getting adequate collections of larvae of the two later generations, which feed almost entirely in the fruit, prevented gathering of reliable information on their parasitism.

Infested peach twigs were collected each year from numbers of two- to five-year-old peach orchards when larvae of the first and second generations reached their respective peaks of abundance. Before 1948, attempts were made to collect 100 twigs from each orchard, but commencing in 1948 all collections were made by spending one man-hour in each orchard, except where the infestation was so low that the entire orchard was examined in less than that time. In Essex County very few, small collections were made in 1942 and none in 1943. Methods of rearing the collected material in an insectary were described by Boyce (1) in 1947. In all cases the percentage parasitism was calculated on the basis of the total number of oriental fruit moth and parasite adults reared from each collection.

#### RESULTS AND DISCUSSION

The percentage of parasitism by each of the most prevalent species, namely *Macrocentrus ancyliivorus* Rohw., *Horogenes obliteratus* (Cress.), *Macrocentrus delicatus* Cress., *Glypta ruficinctellaris* Cress., and *Cremastus minor* Cush., is given in Tables I to IV, and the average percentage parasitism by *M. ancyliivorus* before and after the use of DDT or parathion or both is given in Table V.

In Essex County during 1936 to 1939, and again during 1946 and 1947, *M. ancyliivorus* was colonized extensively. These colonizations temporarily increased the numbers of the parasite, but it rapidly declined after colonization ended. In the Niagara Peninsula, however, the parasite was not liberated after 1935. Despite these differences it is evident from the data in the tables that both generations of *M. ancyliivorus* have been consistently more abundant in the Niagara area than in Essex County since 1939.

The situation with regard to the native parasite *M. delicatus* was just the reverse; this species has always been much more abundant in Essex County than in the Niagara Peninsula. The reason for this difference is not known. *M. delicatus* continues to be abundant on the ragweed borer, *Epiblema strenuana* (Wlkr.), in the Niagara district.



Table II

PERCENTAGE PARASITISM OF SECOND-GENERATION LARVAE OF THE ORIENTAL FRUIT MOTH FROM TWIGS IN YOUNG ORCHARDS, ESSEX COUNTY, ONT., BEFORE AND AFTER DDT OR PARATHION, OR BOTH, CAME INTO GENERAL USE

Year	No. of orchards	Total moths reared from collections	Parasite											
			M. <i>ancylivorus</i>		Glypta <i>rufiscutellaris</i>		M. <i>delicatus</i>		C. <i>minor</i>		Others		Total	
			No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
1939	10	216	403	31.7	542	42.7	1	0.1	29	2.3	79	6.2	1054	83.0
1940	8	215	139	27.6	129	25.6	—	—	—	—	20	4.0	288	57.2
1941	9	78	48	13.6	206	58.5	—	—	5	1.4	15	4.3	274	77.8
1942	8	20	19	10.3	143	77.3	—	—	—	—	3	1.6	165	89.2
1943	0													
1944	7	21	4	2.5	122	76.2	—	—	3	1.9	10	6.2	139	86.8
1945	6	90	42	5.0	682	81.8	—	—	1	0.1	19	2.3	744	89.2
1946	24	847	677	18.6	1916	52.6	1	0.03	46	1.27	158	4.3	2798	76.8
1947	22	1221	1511	51.3	100	3.4	19	0.6	74	2.5	20	0.7	1724	58.5
1948	22	1784	737	24.3	441	14.6	47	1.6	12	0.4	8	0.2	1245	41.1
1949	26	1921	839	29.1	40	1.3	78	2.7	4	0.15	2	0.05	963	33.3
1950	31	553	540	46.6	14	1.2	50	4.3	—	—	2	0.2	606	52.3
1951	36	1252	913	40.0	13	0.6	99	4.4	—	—	3	0.1	1028	45.1
1952	26	1671	694	26.9	21	0.8	192	7.4	—	—	2	0.1	909	35.2
1953	22	1601	588	20.7	106	3.7	538	19.0	—	—	2	0.1	1234	43.5





Table IV

PERCENTAGE PARASITISM OF FIRST-GENERATION LARVAE OF THE ORIENTAL FRUIT MOTH FROM TWIGS IN YOUNG ORCHARDS, NIAGARA PENINSULA, ONT., BEFORE AND AFTER DDT OR PARATHION, OR BOTH, CAME INTO GENERAL USE

Year	No. of orchards	Total moths reared from collections		Parasite										
				M. <i>ancyliivorus</i>		G. <i>rufiscutellaris</i>		M. <i>delicatulus</i>		C. <i>minor</i>		Others		
				No.	%	No.	%	No.	%	No.	%	No.	%	
1939	32	1210	1961	53.2	371	10.1	—	—	94	2.5	52	1.4	2426	67.2
1940	26	834	2185	68.8	49	1.5	—	—	25	0.8	82	2.5	2341	73.6
1941	11	96	215	60.2	38	10.6	—	—	2	0.5	6	1.6	261	72.9
1942	30	378	169	12.1	835	59.9	—	—	5	0.3	6	0.4	1015	72.7
1943	39	1190	1391	32.1	1366	31.6	—	—	309	7.1	71	1.6	3137	72.4
1944	22	146	126	34.1	36	9.7	—	—	57	15.4	4	1.2	203	60.4
1945	42	4727	2845	31.4	1287	14.2	—	—	171	1.9	20	0.2	4323	47.7
1946	39	481	1293	58.5	268	12.1	—	—	157	7.1	11	0.5	1729	78.2
1947	40	301	131	30.3	—	—	—	—	—	—	—	—	131	30.3
1948	47	2463	2823	47.0	28	0.6	—	—	122	2.5	3	0.1	2476	50.2
1949	38	918	1135	50.4	27	1.2	—	—	170	7.6	—	—	1332	59.2
1950	39	533	1238	67.4	27	1.5	—	—	37	2.0	1	0.1	1303	71.0
1951	33	485	551	52.6	7	0.7	—	—	1	0.1	3	0.3	562	53.7
1952	28	388	895	69.6	—	—	—	—	3	0.2	—	—	898	69.8
1953	26	188	515	72.2	—	—	—	—	8	1.1	2	0.3	525	73.6

Table V

AVERAGE PERCENTAGE PARASITISM BY *M. ANCYLIVORUS*  
BY AREAS AND PERIODS

Period	Essex County		Niagara Peninsula	
	1st gen.	2nd gen.	1st gen.	2nd gen.
1939-1947, before DDT or parathion or both were used	5.8	27.0	24.0	43.0
1948-1953, after DDT or parathion or both were introduced	20.1	31.3	42.3	59.9

Before the use of DDT and parathion there were no marked differences in the abundance of the other native parasites in the two peach-growing areas, except that *G. rufiscutellaris* was usually more abundant in Essex County.

The tables, especially Table V, indicate clearly that since DDT has been used, and more recently parathion in the Niagara area, there has been a general increase of the first generation of *M. ancyliovorus* in Essex County and of both generations in the Niagara Peninsula, although yearly fluctuations were somewhat more marked in Essex County.

Although many factors, notably weather conditions, may affect the abundance of the parasite and its host, it is evident that DDT, in association with these other factors, whether favourable or otherwise, did not adversely affect the abundance of this species. It is possible that DDT and parathion each favoured the parasite in some indirect, unknown manner.

Similarly, the population of *M. delicatus* has steadily increased in Essex County since DDT was introduced, and the increase was particularly evident in 1953, when parasitism of both generations reached levels far above those of the 26 years for which records are available. This species remained at a very low level in the Niagara area.

Tables I and III indicate that *H. obliteratus* has been somewhat reduced in numbers in both areas since spraying with DDT and parathion became general practices.

The only apparently clear case of a marked reduction of a parasite of the oriental fruit moth by DDT, and possibly parathion, is afforded by *G. rufiscutellaris*. Tables II and IV show that, before these insecticides were used, this species was an important parasite of second-generation larvae, but that, except in 1948 in Essex County, it has been present in drastically reduced numbers since. In the Niagara Peninsula and Essex County it is still a common parasite of its native host *Epiblema strenuana*.

### SUMMARY

The introduced parasite *Macrocentrus ancyliovorus* Rohw. appears in some manner to have been favoured by DDT and parathion applied for the control of the oriental fruit moth in commercial peach orchards of Essex County and the Niagara Peninsula (Lincoln and Welland counties).

A native parasite, *Glypta rufiscutellaris* Cress., has rapidly decreased in abundance during the six years that DDT or parathion has been in general use in Ontario peach orchards.

Most of the less effective species of native parasites appear to have been unaffected by the applications of these two chemicals; but *M. delicatus* in Essex County, where it has always been



more abundant than in the Niagara Peninsula, appears to have been aided by the insecticidal treatments, or favoured by some other environmental change. Populations of *Horogenes obliteratus* (Cress.) appear to have been somewhat reduced by DDT and parathion.

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# NOTES ON INTRODUCED PARASITES OF THE EUROPEAN PINE SHOOT MOTH, *RHYACIONIA BUOLIANA* (SCHIFF.) (LEPIDOPTERA: TORTRICIDAE), IN ONTARIO<sup>1</sup>

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The European pine shoot moth, *Rhyacionia buoliana* (Schiff.), was first recorded in Canada in 1925, although it was present in the United States at Long Island, New York, in 1914. Both the moth and some of its natural enemies have been intercepted from time to time in nursery stock from Europe, by officers of the Plant Protection Division, Science Service, at ports of entry. The pest feeds on the native pines *Pinus strobus* L. and *Pinus resinosa* Ait. as well as on many introduced European species used as ornamentals and for plantations.

Because of the increasing importance of the European pine shoot moth as a plantation pest in southern Ontario a program for the introduction of natural agents of control was initiated. With the co-operation of the Farnham House Laboratory, Farnham Royal, England, the first shipment of parasites was received in 1928. Since then, releases have been made sporadically

TABLE I  
Species, numbers, years of releases, and origins of  
parasites released against *R. buoliana* in southern Ontario, 1928 to 1953

<i>Species</i>	<i>No. released</i>	<i>Years released</i>	<i>Origin</i>
<i>Calliephialtes comstockii</i> (Cress.)	286	1932-43	Canada
<i>Campoplex mutabilis</i> (Holmg.)	2,132	1928-43	England
<i>Campoplex rufifemur</i> (Thoms.)	797	1935	England
<i>Copidosoma geniculatum</i> (Dalm.)	16,698	1934-36	Europe
<i>Cremastus interruptor</i> (Grav.)	29,998	1928-49	England, Canada
<i>Ephialtes ruficollis</i> (Grav.)	7,032	1933-42	England
<i>Orgilus obscurator</i> (Nees)	8,878	1928-49	England, Canada
<i>Pimpla</i> spp.	688	1932-33	England, Canada
<i>Pimpla turionellae</i> (L.)	2,512	1935-53	Europe
<i>Tetrastichus turionum</i> (Htg.)	1,570	1938	Europe

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TABLE II

Species of parasites reared from collections of *R. buoliana*,  
and percentages of parasitism, from various localities in southern Ontario in 1953

Species	Collection Area					
	Brighton	Brock's Monument	Hamilton	Kingsville	Niagara Falls	Sandbanks (near Picton)
Introduced						Vineland
<i>Cremastus interruptor</i> (Grav.)	0.04	0.64	0.00	0.00	4.75	0.00
<i>Orgilus obscurator</i> (Nees)	2.00	1.41	8.87	0.00	5.63	1.96
<i>Tetrastichus turionum</i> (Htg.)	0.00	0.00	0.00	5.06	0.00	0.00
Native						
<i>Calliephialtes comstockii</i> (Cress.)	0.22	0.13	0.00	0.00	0.10	0.00
<i>Campoplex</i> sp.	0.00	0.13	0.00	0.00	0.00	0.00
<i>Eurytoma appendigaster</i> (Swed.)	0.00	0.26	0.00	0.25	0.00	0.00
<i>Habrocytus</i> sp.	0.07	0.00	0.00	0.25	0.00	0.00
<i>Hyssopus thymus</i> Gir.	0.25	0.00	0.00	2.28	0.19	0.00
<i>Itoplectis conquisitor</i> (Say)	0.36	0.26	0.60	0.00	0.00	0.00
<i>Itoplectis</i> sp.	0.04	0.00	0.00	0.00	0.00	0.00
<i>Scambus hispae</i> (Harr.)	0.22	0.51	0.07	0.00	0.19	0.00
Undetermined	0.14	0.00	0.47	0.76	0.00	0.00
Total percentage parasitism	3.34	3.34	10.01	8.60	10.86	1.96
						6.73

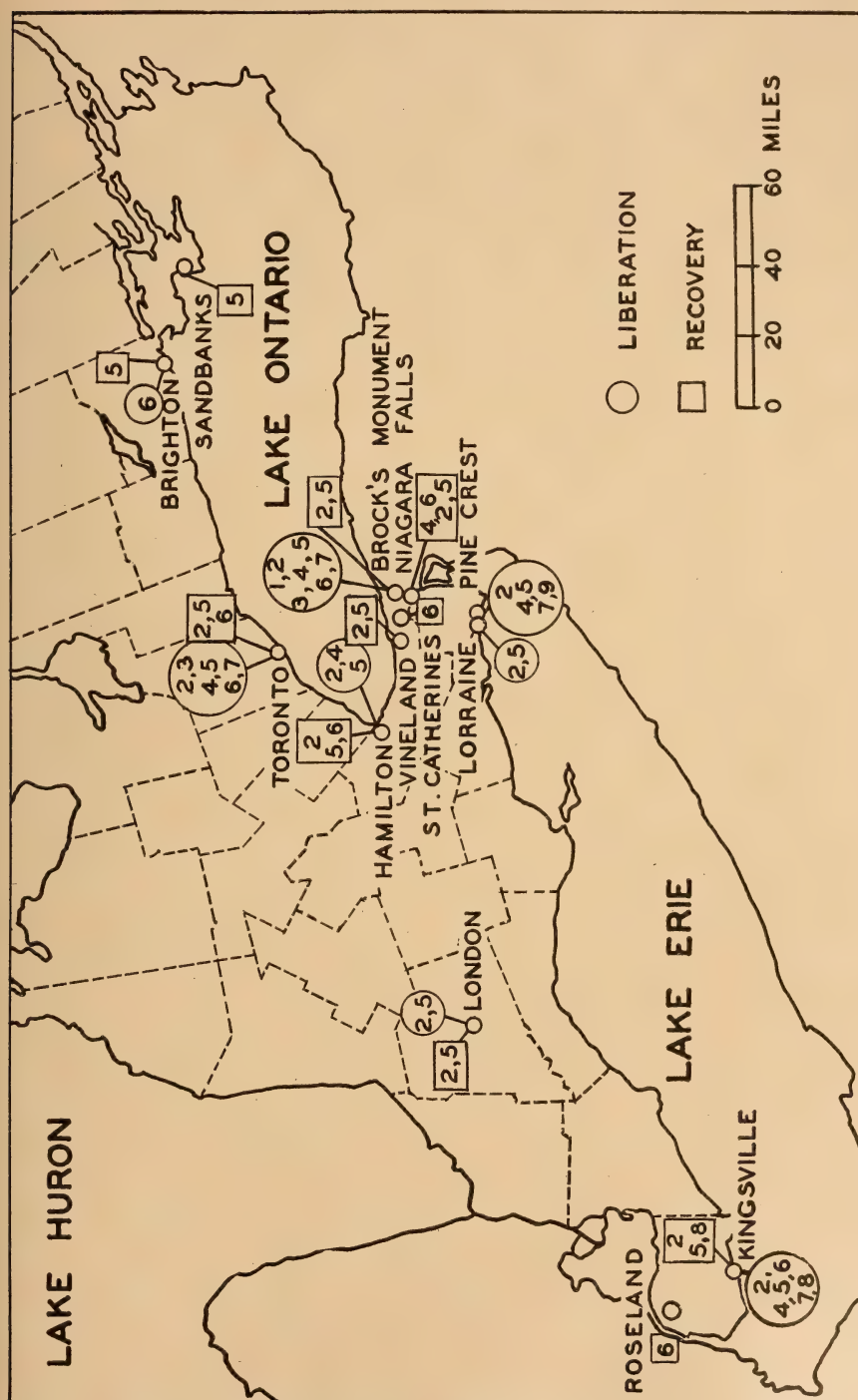


Fig. 1. Liberations and recoveries of introduced parasites of the European pine shoot moth, *R. buoliana*, in Ontario, 1928-1953:  
1, *Copidosoma geniculatum*; 2, *Cremastus interruptor*; 3, *Campoplex ruffianus*; 4, *Campoplex mutabilis*; 5, *Orgilus obscurator*;  
6, *Pimpla turionellae*; 7, *Ephialtes ruficollis*; 8, *Tetrastichus turionum*; 9, *Pimpla* sp.



until the present. These have been confined to areas of severe infestation mainly near Toronto, Hamilton, Niagara Falls, Kingsville, and Brighton. Ten species of parasites have been released, the majority of which originated in England (Table I). The others originated either from collections in continental Europe or from collections of the host made in Ontario. In the latter instance, redistribution of the exotic parasites that had become established and of two native parasites (*Calliephialtes comstockii* (Cress.) and *Pimpla* sp.) was undertaken.

More than 7,000 larvae and pupae of *R. buoliana* were collected in 1953 and reared singly in vials at Belleville. The results of the rearings, including the native parasites, are shown in Table II. Although eight native species and only three introduced species were recorded, the introduced species were the most abundant. Total parasitism ranged from 1.96 to 10.86%; the introduced parasites contributed two-thirds or more of the total in all areas. *Orgilus obscurator* (Nees) was the most abundant and widespread of the introduced species; *Cremastus interruptor* Grav. was second in importance. The occurrence of *Tetrastichus turionum* (Htg.) in the Kingsville area is the first record of the establishment of this species in Canada; it was also more abundant at the time of collection than any native parasite obtained in the area.

Records at the Belleville laboratory on recoveries of other introduced species are as follows: one female of *Campoplex mutabilis* (Holmg.) was obtained at Niagara Falls in 1943, one female of *Pimpla turionellae* (L.) from Roseland in 1937, and other recoveries from St. Catharines, Hamilton, Niagara Falls, and Toronto in 1941 and Hamilton in 1943. The other species, *Copidosoma geniculatum* Dalm., *Campoplex rufifemur* (Thoms.), and *Ephialtes ruficollis* (Grav.), have not been recovered from *R. buoliana* to date.

The introduced species released and recovered by the staff of the Belleville laboratory, and the localities, are shown in Fig. 1. Not all the localities for *C. interruptor* and *O. obscurator* are shown since these species are widespread, having been transported in infested nursery stock.

It is now impossible to ascertain the particular species of *Pimpla* other than *turionellae* that were reared from imported material and from local collections and later released.



## INTRODUCTION INTO CANADA OF PARASITES OF THE CARROT RUST FLY, *PSILA ROSAE* (F.) (DIPTERA: PSILIDAE)<sup>1</sup>

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The carrot rust fly, *Psila rosae* (F.), was described by Fabricius in 1794. By 1889 it was recorded over most of western Europe. The first record of its presence in North America was made at Ottawa, Ontario (Fletcher, 1885, p. 15). It was first observed in British Columbia in 1934 (Glendenning, 1938) and was soon found over the whole of the lower Fraser Valley (Glendenning, 1942) and in the interior (Handford and Neilson, 1951). Severe losses have occurred in British Columbia, Ontario, and elsewhere in areas where carrots are grown commercially. By 1916 it was present in such numbers in the Holland Marsh area of Ontario that there was an estimated loss of 50,000 to 100,000 bushels of carrots (Goble, 1947).

The following parasites of the carrot rust fly have been recorded in England by Wright, Geering, and Ashby (1947): *Dacnusa gracilis* (Nees) (Hymenoptera: Braconidae), *Loxotropa tritoma* (Thoms.) (Hymenoptera: Proctotrupoidea), *Aleochara sparsa* Heer (Coleoptera: Staphyl-

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inidae), and *Kleidotoma* spp. (Hymenoptera: Cynipidae). Nixon (1937) reported *D. postica* Hal., later synonymized with *D. gracilis* (Nixon, 1944), as having been reared from *P. rosae* in Switzerland. Savzdarg (1927) stated that in the Leningrad area of Russia 20 per cent of the *P. rosae* puparia were parasitized by *Dacnusa* spp. in 1924 and 35 per cent in 1925. Of the parasite species listed in England by Wright *et al.* (1947), *D. gracilis* and *L. tritoma* are the only ones of importance in the biological control of this host; both are widespread in the carrot-growing areas of East Anglia, *D. gracilis* being the more numerous.

No records of parasite attack on the fly in America were found, but some of the parasites might have been introduced and established at the same time as the host. Therefore during 1948 and 1949 first- and second-generation larvae, first-generation puparia, and hibernating puparia of the overwintering generation of the fly were collected in the Holland Marsh and incubated in the laboratory. No parasites were obtained. Since the fly is known to be an introduced species, its control by biological means appeared possible. The studies reported in this paper were initiated in 1948 at Belleville.

#### INTRODUCTION AND RELEASE OF PARASITES

By arrangement with the Commonwealth Institute of Biological Control and later directly with agricultural research workers in England, puparia of the fly were collected and shipped to Canada. After arrival at Belleville, sample lots were reared to determine the incubation period required for adult emergence. The remaining puparia were stored at 3.3°C. in a mixture of soil and shredded sphagnum moss in ventilated metal containers. The soil was kept slightly moist throughout storage.

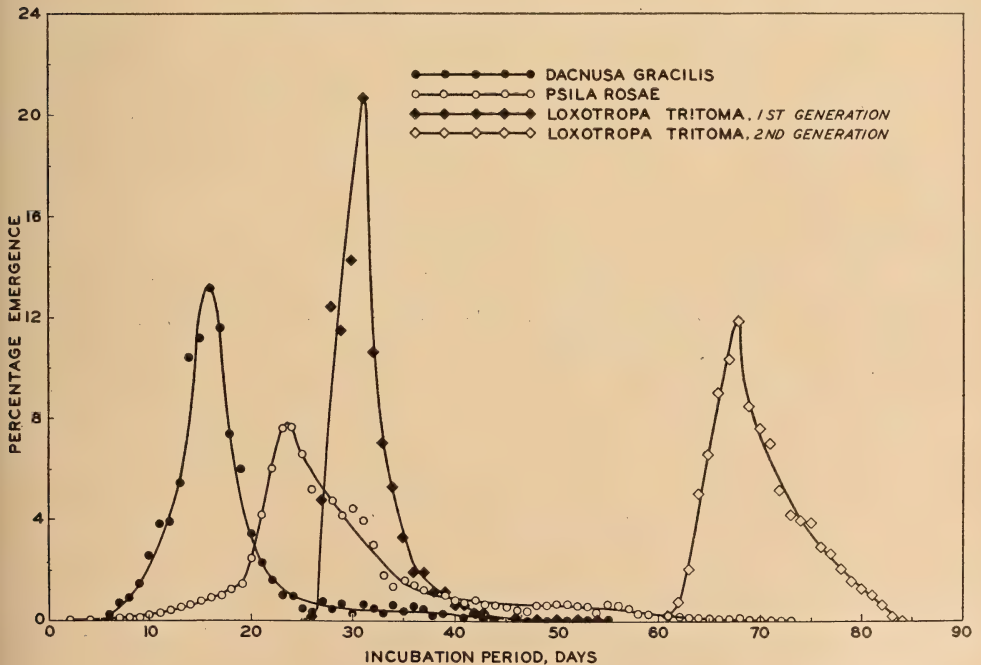


Fig. 1. Emergence of *Psila rosae* (F.) and its parasites, *Dacnusa gracilis* (Nees) and *Loxotropa tritoma* (Thoms.), from soil at 25 per cent saturation in the laboratory at 21.1° air temperature and 40 per cent relative humidity (some points not plotted where the curves for *D. gracilis* and *L. tritoma* overlap).

To rear the parasites for release, the puparia were incubated at 21.1°C. in the soil in which they were stored. The soil was placed in 8-inch earthenware saucers in rearing cages, the sides and tops of which were of fine-mesh bolting cloth. The soil was moistened and stirred daily to maintain a uniform 25 per cent saturation as found by Whitcomb (1938) to be the most favourable for emergence. Adults emerged over a period of 85 days (Fig. 1). *D. gracilis* adults were easily gathered from the sides of the rearing cages. *L. tritoma* adults are negatively phototrophic and, though many were collected off the sides of the cages, many more remained in the soil where they emerged. Here they parasitized host puparia that had not previously been attacked. Normally *L. tritoma* remains in diapause over winter, but when it attacks host puparia in which the diapause is satisfied development continues in the laboratory without diapause.

Parasites were released in British Columbia at Armstrong and Cloverdale, in Ontario at Bradford, and in Prince Edward Island at Charlottetown and St. Eleanor's, *D. gracilis* when the host was in the first and second instars and *L. tritoma* when host puparia were present (Table I). Dates for releases were supplied by agricultural research workers in the field. They were shipped to release points in iced containers by railway express. *D. gracilis* adults were packed in copper shipping cans, but because *L. tritoma* adults could escape through very small crevices they were put in pint milk bottles; there was less mortality in storage before and during shipment if a short length of slightly moistened dental cotton was suspended from the cap of the bottle. *L. tritoma* required several hours to leave the bottles at the release point, whereas *D. gracilis* issued from the cans immediately. The parasites were liberated in the afternoon when the air temperature was between 65 and 72°F., in carrot fields moderately to severely infested. All of *D. gracilis* released were reared from imported collections but those of *L. tritoma* included laboratory-propagated stock.

TABLE I

Numbers of parasites released against *Psila rosae* (F.) in Canada, 1949-1953.

	<i>Dacnusa gracilis</i> (Nees)					<i>Loxotropa tritoma</i> (Thoms.)				
	1949	1950	1951	1952	1953	1949	1950	1951	1952	1953
British Columbia										
Armstrong				1475	3111				7400	12,256
Cloverdale	1163	279	4962				9984	9386		
Ontario										
Bradford	1897	495	4826			291	30,814	4980		
Prince Edward Island										
Charlottetown					1012					
St. Eleanor's										10,362

#### FIELD STUDIES AND RECOVERIES

Field studies on the parasites were conducted in 1951 at the Holland Marsh. Four cotton cages, 3 by 4 by 6 ft., were placed over carrots in an area severely infested with the fly. *D. gracilis* adults were released in two of the cages; in one the host larvae were in the first and second instars and in the other in the third instar. *L. tritoma* adults were released in the other cages when the host was in the pupal stage because it had been found in the laboratory that *L. tritoma* parasitizes the puparia, rather than the last-stage larva as reported by Wright *et al.* (1947). Carrots were collected at weekly intervals from the *D. gracilis* plots and all host larvae found were dissected. Host puparia were later collected from all the cages and incubated in the laboratory for adult emergence.



One *D. gracilis* larva was dissected from an early-third-instar host obtained from cage 1, in which the host was in the first and second stages when the parasites were released. Puparia collected from this cage produced five parasites (Table II). No parasites were recovered from cage 2, in which the *P. rosae* larvae were in the third instar when the parasites were released. Host puparia collected from cages 3 and 4, into which *L. tritoma* had been introduced, yielded 231 parasites.

TABLE II

Numbers of parasites reared in field cage trials at Bradford, Ont.

Cage No.	Parasite species	No. released	Stage of host	Host puparia collected	adults reared	Parasites emerged
1	<i>D. gracilis</i>	247 ♂ ♂ 237 ♀ ♀	1st and 2nd instar	306	227	5
2	<i>D. gracilis</i>	247 ♂ ♂ 226 ♀ ♀	3rd instar	623	432	0
3	<i>L. tritoma</i>	1691 ♂ ♂ 1373 ♀ ♀	pupa	430	112	148
4	<i>L. tritoma</i>	1155 ♂ ♂ 1000 ♀ ♀	pupa	225	102	83

To determine the survival of *L. tritoma* under Canadian winter conditions, puparia of the fly, after exposure to the parasites in the laboratory, were buried in soil to a depth of four inches in a copper screen cage at the Holland Marsh. In the spring, they were removed and reared in the laboratory. From 140 host puparia incubated, 70 of *L. tritoma* emerged. Because of lack of specimens, tests were not conducted on *D. gracilis*.

Parasite recovery studies were conducted at the Holland Marsh, Bradford, Ont., from 1950 to 1953. Larvae and puparia of the fly were collected from the general area in which parasites had been released. Larvae were obtained by gathering infested carrots, burying them in moist sand, and allowing the larvae to pupate. Puparia were collected by washing soil, obtained from around injured carrots, through three screens on top of one another, with water under pressure. The top two screens were 4-mesh, the third 24-mesh. The finer particles of the soil formed a layer of silt over the fine screen. This caused the water to rise above the bottom of the second screen, and when it was allowed to subside the puparia were picked off the surface of the thin residual layer of debris.

After two months' storage in moist soil at 3.3°C., most of the puparia from the collections were reared individually in 2-inch shell vials in a humidity cabinet at 21.1°C. and 80–85 per cent relative humidity. The vials were stoppered with 5-mm. lengths of rubber tubing ensheathed in 20-mm. squares of fine-mesh bolting cloth (Col'houn, 1953). Nine collections were reared individually and three in bulk in moist soil. Collections made in 1951 produced three of *D. gracilis* and 38 of *L. tritoma* but those in 1952 and 1953 yielded none.

#### SUMMARY

*Dacnusa gracilis* (Nees) and *Loxotropa tritoma* (Thoms.) were released against the carrot rust fly, *Psila rosae* (F.), in British Columbia, Ontario, and Prince Edward Island. The early stages of the host larvae are attacked by *D. gracilis*. *L. tritoma* adults attack the host puparia rather than the last-stage larva. In field tests *L. tritoma* survived winter in the Bradford, Ont., area. Whether *D. gracilis* can survive the winter there was not determined because of lack of

specimens. Efforts to rear the latter in the laboratory have so far been unsuccessful. Adults of both species were recovered in 1951 at Bradford, Ont., the year they were released, but no recoveries have been obtained since.

#### ACKNOWLEDGMENTS

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## RAPID INSECTICIDE TESTS WITH APHIDS

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## I: INTRODUCTION

The aim of modern Insect Toxicology could, perhaps, be defined as the development of better, more persistent and more specific poisons, which, if possible, will kill only the insects we want killed and at the same time will inhibit the development of resistant strains.

The search for new insecticides must be carried out empirically for despite a considerable knowledge (*vide* Brown, Hoskins, Metcalf, Musgrave) there seems to be no precise information available on the mode of action of insecticides. In order, therefore, to test the validity of each new theory it is necessary to resort to the practical testing of many compounds. A rapid, reliable and accurate screening method is therefore desirable; moreover, it may be necessary to test compounds by more than one method.

Such work should proceed concurrently with physiological work on the more fundamental aspects of the subject.

The technique for rapid testing described in this paper employs a well-known spray apparatus in conjunction with an apparatus for the rapid breeding of aphids.

The paper details the best procedure we had devised by the end of 1953.

## II: EQUIPMENT

i) *Spray tower*

Insects are treated by direct spray in a Potter tower (Potter, 1952). This is a piece of custom-built apparatus designed to deliver controlled equitable doses of insecticide over a standard area. It produces a very even deposit of insecticide and permits of very rapid work, even with a single operator. The tower is shown in diagram form in Fig. 2. It consists essentially of a tapered cylinder open at both ends and supported vertically with an angle-iron framework. At the top of the cylinder a precision-made adjustable nozzle is mounted centrally and supported by three steel rods which may be centred and levelled by the adjustment of the appropriate knurled nuts. A circular metal plate is mounted at the base of the cylinder and forms the spray platform; its height is adjustable. For spraying it is normally brought rapidly to within  $\frac{1}{4}$ " of the tower base by a counterpoised lever. The whole framework of the tower is mounted on levelling screws and provision is made for grounding the apparatus. This is important as the spray droplets issuing from the nozzle are electrically charged. Full details of construction are given in Potter's paper.

The tower is supplied with compressed air from a regulated air compressor supplying air at 45 to 75 lbs. per square inch. This air is led through a series of valves and meters to the tower (Fig. 1). Our flow meter is of the kind used on oxygen cylinders and consists of a steel ball in a glass tube. The cushioning reservoir helps to ensure an even air flow. The dose\* of insecticide delivered by the tower may be varied by varying the volume of insecticide fed to the tower, the concentration of toxicant per unit volume, the air pressure and the air flow, the nozzle adjustment and the gap between the tower base and the spray plate.

The mean weight of liquid deposited on the base plate during most of the work described here with benzene emulsion was 4.50 mgm., (Standard Deviation =  $\pm 0.678$ ) on an area of 380 square millimeters or 0.012 mgm. per square millimeter.

\*Following Finney (1945) we reserve the use of 'dosage' to mean any function of the 'dose', such as log, dose, reciprocal of dose, etc.



### ii) Reliability of spray tower performance

A check is kept on the constancy of spray tower performance by weighing the deposit of spray given by the different volumes of insecticide. During our routine investigations weighing checks are made every Friday. The method is as follows:

Small glass coverslips (for microscopic use) are weighed in weighing bottles with stoppers — one coverslip in each bottle. The slips are sprayed by placing them one at each of the front, back, and right and left sides of the base plate of the tower. After being sprayed under standard

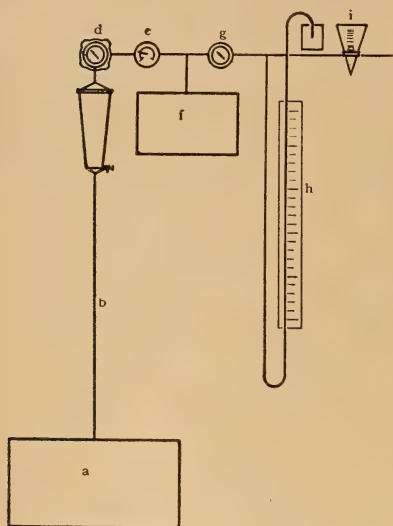


Fig. 1.

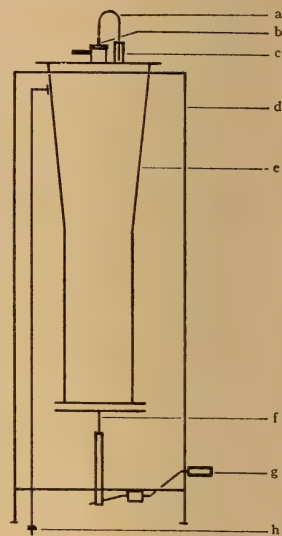


Fig. 2.

Fig. 1. Arrangements of valves to supply air to the tower. (Diagrammatic) a, compressor; b, airline; d, air filter and reducing valve; e, pressure meter; f, air reservoir for cushioning pressure changes; g, needle valve; h, manometer (not always used); i, flow meter.

Fig. 2. Potter Tower (Diagrammatic). a, feed tube; b, nozzle; c, reservoir for spray liquid; d, metal frame; e, tapered cylinder; f, basal plate; g, counterpoised lever; h, grounding wire. The tower is 54 inches high.

conditions they are quickly removed from the plate, placed in bottles and reweighed. Variations in weight are rarely more than 0.1 mgm. per coverslip of size 380 sq. mm. — and this is deemed satisfactory. The balance used for this work is a swing-damped, semi-automatic type.

### iii) Aphid rearing apparatus

Currently, we are rearing two species of aphid: *Aphis fabae* (Scop.), the bean aphid, a black species; and *Macrosiphum pisi* (Kaltenbach), the pea aphid, a green species. We use a slight modification of an apparatus designed by Kennedy and Booth (1950) for the mass rearing of the aphids. We rear the two species of aphids simultaneously. The apparatus is capable of yielding 1000 aphids per day. Normally it is possible to obtain several hundred of each species that are suitable for spraying.

Essentially, the apparatus consists of a number of cages which can be moved along the top of a trough which forms a stand and also acts as a duct through which air may be blown. The duct is U-shaped and the cages are supported over its open top. The cages are 12" x 13" x 16" in dimension. Each cage has its top and two sides of glass; the other two sides are covered with fine mesh gauze. In the original apparatus of Kennedy & Booth, this part of each cage was made so that it could be readily dismantled for cleaning and sterilization. We have so far successfully used cages in which this part was of permanent construction. The bottom of each cage is

open and carries a rubber gasket and fits neatly on to its base plate. Each base plate forms a floor for its cage and part of the roof of the duct. The base plates have each one hole 6" in diameter and six smaller holes. The large hole takes a 6" paper plant pot with a snug fit and the six small holes are screened and serve to admit air from the duct below. The paper plant pots contain potting soil and serve to grow broad beans upon which both species of aphids feed. The gauze-covered inlets in the base plates are shielded from cast skins and honey dew by flat metal rings that rest on the tops of the plant pots. The gauze protects the aphids from parasites and the airstream from the duct retards mould growth.

The duct is T-shaped and air is drawn in by a fan in the leg of the T. By appropriate arrangement of flaps and twisters, air can be drawn into the duct from either outside or inside the building. Each position on the duct is numbered and cages start at position 1 with young beans and a starting population of aphids and they are removed at position 11 (or 10 and 11) with a greatly increased population. In our work we run alternating cages of *Aphis fabae* and *Macrosiphum pisi*. Bean growth is encouraged during the winter months by light from two fluorescent tubes hung over the cages.

### III: BIOLOGICAL MATERIAL

#### *Establishment and maintenance of Insect Cultures*

Efforts to establish the black aphid, occurring in great numbers on the local burdock, failed. There was no apparent reason for this. The aphids would settle on our bean plants for a short time and then die or move off the plant. Eventually black aphids from Lambs' Quarters (*Chenopodium album*) established themselves on our beans and produced generations that were reared through the winter in the summer stage—they were all parthenogenetic, viviparous females, alate or apterous. These became our stock of *Aphis fabae*. As we found that a large green species (subsequently identified as *Macrosiphum pisi*) could easily be established on our laboratory beans we decided to include it in our rearing programme, and thus have two species for test. This method of breeding the two species in alternate cages in the same apparatus has proved very successful. These aphids, both known to exist as several different strains, (see Harrington; Jacob; and Jones;) established themselves most readily on the very young bean sprouts.

We have been able to maintain colonies by collecting aphids from the cage at position No. 11 and placing them on young sprouting beans at position No. 1.

We have kept a vigilant check on the health of our aphids and since we first set up our rearing programme it has been necessary once only to restock our *Aphis fabae*, which had become diseased. Our *M. pisi* are all offspring of the original stock.

### IV: CHEMICAL MATERIAL

This paper describes tests on a wide variety of compounds, mostly chlorinated hydrocarbons. No organo-phosphorus compounds were tested. Most of the compounds were synthesised and supplied by Drs. M. Kulka and F. Stryk of the Dominion Rubber Company. For further information, reference should be made to Kulka (1954). A few other compounds were made by Dr. W. H. Brown of the Chemistry Department, Ontario Agricultural College.

### V: METHODS

#### i) *Handling and Collecting of Aphids*

In most of our work it is very desirable to have aphids, an estimate of whose age can be made; and to ensure that the aphids are damaged as little as possible in handling.

Three methods can be adopted to obtain aphids of uniform age:

a) 100 alate females are used to start a new culture. We then know that all apterous adult females that subsequently appear are of reasonably uniform age.

- b) If we start cultures from nymphs of about the same age we can obtain the required adults.
- c) Cultures can be started from mixed adults which can be removed three days later. The progeny, which form the culture, will be of uniform age.

We use two methods for collecting the aphids:

- a) *Macrosiphum pisi* has the habit of dropping from the plant when even slightly disturbed. We make use of this by placing a receptacle beneath the plant to catch the aphids.
- b) We find that it is necessary to collect *Aphis fabae* with a camel's hair brush. Usually they are collected as adults just beginning to wander.

Twenty aphids are used in each population sample. They are collected 1 — 2 hours before spraying and kept in stoppered conical flasks until the operator is ready to spray them.

#### ii) *Spraying*

The air is supplied to the tower and the needle valve opened so that air is passing through the tower. The prepared solutions are handy and at the appropriate time they are supplied to the tower reservoir by an automatic pipetting unit adjusted to deliver the required volume of spray. We find this automatic pipetting unit, which is a modified hypodermic syringe, very useful in enabling us to handle quickly and efficiently, measured volumes of liquid.

Aphids are tipped from each conical flask on to a Whatman No. 3 filter paper 11 cms. in diameter. This filter paper is then quickly placed on the basal plate of the spray tower which is immediately raised to the predetermined position. The required volume of spray is then quickly supplied to the reservoir and sprayed on to the aphids. As soon as all the liquid in any one dose has been sprayed the basal plate is lowered and the filter paper with the aphids removed. These aphids are then tapped from the filter paper into an inverted glass lantern globe.

Between sprayings the tower is washed by filling the reservoir with some appropriate liquid and spraying this through the apparatus. Most of our work to the end of 1953 has been with benzene emulsions: cleaning the tower by washing through twice with water, once with alcohol and then again twice with water. At the end of each experiment the tower is given a more thorough clean and is wiped dry.

#### iii) *Assignment of aphids after spraying*

As previously noted, sprayed aphids are tapped from the filter paper, on which they have been sprayed, into inverted lantern globes. The inverted tops of these globes are supplied with cheese-cloth held in place by elastic bands. The globes containing aphids are carried to the post-treatment room where each one is placed right way up over a bean plant, growing in potting soil in a small plant pot. Each pot is contained in a glass ointment jar. Aphids that fall from the globe or the bean plant are prevented from being lost in the soil of the pot by a filter paper placed over the rim of the ointment jar and slotted to fit around the bean stalk (Fig. 3). We use potted bean plants because our experience is that aphids placed on cut bean stalks in water as recommended by Tattersfield and Morris (1923) fail to establish themselves satisfactorily and consequently die.\*

#### iv) *Mortality Counts*

We make a rough count 24 hours, and an accurate count 48 hours, after spraying. We use the following criteria of "death":

##### *Macrosiphum pisi*

Dead: those lying motionless in an abnormal manner; sometimes with legs extended irregularly and dry and brittle; body shrivelled and often discoloured. No response, by movement, to touch.

Moribund: locomotion slow and poorly co-ordinated; unable to climb up the plant; or unable to right themselves when lying on their backs, although legs may be moving.

\* The explanation of this may, perhaps, lie in the biochemical changes in the cut leaf (Chibnall, New Phytol., 53: 31) and aphid nutritional requirements (Symposium, Tijdschr. Ent., 95: 59).



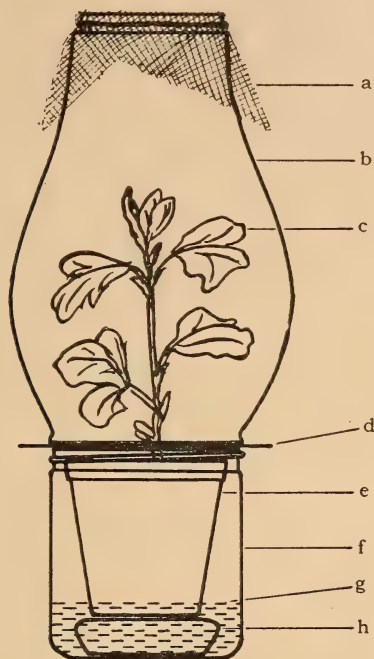


Fig. 3. A Post-treatment cage. a, muslin cover; b, glass lantern-globe; c, bean plant; d, filter paper; e, plant-pot; f, ointment jar; g, water; h, pot support. The globe is 7 inches high.

#### *Aphis fabae*

Dead: lying motionless and in an abnormal manner, with legs and antennae in disorder. Body dry and shrivelled. No response, by movement, to touch.

Moribund: As for *M. pisi*.

Observation showed that aphids showing these signs of toxæmia never recovered: all such aphids were therefore classed as "dead".

#### v) Controls and checks

In our standardised procedure we usually screen four new compounds in each test. We first try them at 1% strength, usually in benzene emulsion (5% benzene), or more recently in a mixture of acetone and water). In each test we run three controls: a population check, a BHC check and a carrier check. The population check is designed to expose any inherent weakness in the biological material. In other words to give us an assessment of natural mortality in the samples under test. The insects in the population check are, of course, not sprayed at all. The BHC check is incorporated to provide a guide to the susceptibility of each sample of aphids to a well known standard insecticide. Our standard BHC check is made from a "Higam 99" BHC, which contains 99% gamma isomer. It is incorporated in the standard benzene emulsion (containing 5% benzene) so as to give an emulsion containing 0.05% benzene hexachloride. On some occasions, because of its greater susceptibility, *M. pisi* was sprayed with 0.025% BHC. In the carrier check we spray a sample of the population under test with the solvent used for insecticides tested that day.

We adopt the following order of spraying:

- i) We spray the compounds under test.
- ii) The tower is cleaned between the spraying of each compound.
- iii) We spray the carrier.
- iv) We spray the BHC.

In this way we hope to keep a check on our method of cleaning the tower. Unsatisfactory cleaning would be revealed most likely by a high mortality in the carrier check.

The insects for the population check are kept in the conical flasks and then transferred into an after-treatment cage, at the end of the experiment. They are not sprayed in any way.

## VI: RESULTS

The experiments are regarded as screening tests and are designed to detect and pick out compounds that are likely to compare favourably with existing compounds. Our work shows that using our present methods any good compound really does stand out. Moreover, distinct differences in the response of the two species of aphids to the various poisons, can sometimes be detected.

It is usually possible to kill insects in the laboratory with compounds that are not or are only slightly toxic simply by drowning them in the compound. We try to apply a dose of each insecticide equivalent to that amount of BHC that nearly or only just causes 100% mortality. If the insecticide under test is as good as or better than this in performance, it can be regarded as a promising compound.

The compounds tested are listed below in three groups; all were administered as 1% solutions active compound in benzene emulsion (5% benzene).

*Group A* Those found non-toxic, in which the mortality with both species of aphids was less than 40%, or not obviously different from check mortality in the few tests where this was greater than 15% for the population check.

*Group B* Those classed as slightly toxic, giving a mortality of 40–60% with either species of aphid, the population check being under 15%.

*Group C* Highly toxic or promising compounds, giving mortalities of 60%–100% mortality to either species of aphids when population check mortality is below 15%. Compounds in this group (except rotenone) were tested three times each.

*Aphis fabae* is more resistant to BHC than *Macrosiphum pisi*. In opposition to this, the compounds 3-nitro-4-methoxy benzyl  $\beta$ -chloroethyl ether and p-Xylylene bis( $\beta$ -chloroethyl ether) are highly toxic to *A. fabae* but almost non-toxic to *M. pisi*, at the 1% level. Thus to spray a mixture of BHC and p-Xylylene bis( $\beta$ -chloroethyl ether) seemed an obvious step.

### *Group A*

N,N'-Tetramethyl-chlorobenzene-2,4-disulfonamide  
Chlorobenzene-2,4-disulfonamide  
N,N'-Di-2-pyridyl-chlorobenzene-2,4-disulfonamide (K salt)  
N,2-Pyridyl p-chlorobenzene sulfonamide (K salt in aqueous sol.)

Hydroxymethyl p-chlorophenyl-sulfone  
p,p'-Dichlorobenzhydyl-p-chlorophenyl sulfone  
p-Chlorophenyl-3,4-dimethoxyphenyl sulfone  
p-Chlorophenyl p-methoxyphenyl sulfone  
Chlorobenzene -2,4- bis-(hydroxymethylsulfone)

Allyl p-chlorobenzene sulfonate  
 $\beta$ -Chloroethyl phenoxybenzene-4,4'-disulfonate  
2-Methyl-2-nitropropyl-p-chlorobenzene sulfonate  
2-Chloro-2-nitropropyl-p-chlorobenzene sulfonate  
2-Chloro-2-nitropropyl-1,3-dichlorobenzene sulfonate  
 $\beta$ -Chloroethyl chlorobenzene-2,4-disulfonate  
Methyl nitrochlorobenzene disulfonate

1,2,3-Trichloropropane  
1-(3-Methoxy-4-hydroxyphenyl)-2-nitro-1-propene

1,4-Bis- (cyanomethyl) benzene  
 1,2,4-Trichloromethyl benzene  
 $\alpha$ -Methoxy- $\beta$ -nitro-p-chloro (ethyl benzene)  
 1-Tert.-butyl-4-tert.-butoxy benzene

2-Nitro-2-methyl-1-propanediol  
 2-Nitro-2-methyl-1-propanol  
 1,1-Dichloro-3-nitro-2-propanol  
 1-Chloro-3-nitro-2-propanol  
 1-Chloro-1-nitro-2-propanol  
 1- (2,4-Dichlorophenoxy) propanol

2,2,4-Trimethyl-1,2-dihydroquinoline  
 1-Nitroso-2,2,4-trimethylquinoline  
 1,2,3,4-Tetrahydroquinoline  
 Chlorinated 1-Acetyl-1,2-dihydro-2,2,4-trimethylquinoline

p,p'-Dichlorobenzhydriyl propyl ether  
 p,p'-Dichlorobenzhydriyl cyclohexyl ether  
 o,p'-Dichlorobenzhydriyl  $\beta$ -chloroethyl ether  
 Benzyl  $\beta$ -chloroethyl ether  
 p-Chlorobenzyl- $\beta$ -chloroethyl ether  
 3,4-Dichlorobenzyl  $\beta$ -chloroethyl ether  
 Trichloro tert.-butyl p,p'-dichlorobenzhydriyl ether  
 p,p'-Dichlorobenzhydriyl tetrahydrofurfuryl ether  
 Lauryl p-chlorobenzyl ether  
 o-Xylylene bis-chloroethyl ether  
 p-Xylylene bis-butoxy ether  
 2-Chloro 2-nitropropyl-p-chlorobenzyl ether

Diphenylamine  
 N-Acetyldiphenylamine  
 N-Formyldiphenylamine  
 2,4',4,4'-Tetrachlorodiphenylamine

p-Chloroethyl benzyl chloride  
 p-Nitrobenzyl chloride  
 1- (2,4-Dichlorophenoxy) propylchloride  
 2,4,5-Trichlorobenzyl chloride  
 p-chlorophenoxyethyl chloride  
 p-Methoxy-phenoxy-ethyl chloride  
 p-Xylylene dichloride  
 2,5-Dichloroxylylene dichloride

2-Phenoxyethanol  
 2,4-Dichlorophenoxy-2-ethanol  
 p-Tert.-butyl phenoxy-2-ethanol  
 2-p-Methoxy phenoxyethanol

2,4-Dichloro-6-phenylphenol  
 o-Isopropylphenol

Veratryl cyanohydrin benzoate  
 Acrolein cyanohydrin benzoate

1,1,1-Trichloro-2-nitro-3-hydroxy-propane  
 3,3-Bis- (p-chlorophenyl) 2-methyl pseudourea  
 10-Chloroacetyl phenothiazine  
 Diphenylcyanamide  
 Diphenyl carbonate  
 Acrylamide  
 Sequestrene A A  
 Ethyl cyanoacetate  
 Paraldehyde  
 Trioxane  
 Dichlorodiphenyl-cyanamide  
 Bis- (2-methoxy-5-tert.-butylphenyl) methane  
 $\beta$ -Chloroethyl terephthalate  
 3-Methoxy-4-hydroxyphenyl acetone  
 4-Tert.-butyl-2-nitroanisole



*Group B*

1,1-Dichloro-3-nitro-2-propanol  
 2-Chloro-2-nitro-1-propanol  
 1,1-Dichloro-3-nitro-2-butanol  
 1,1,1-Trichloro-2-acetoxy-3-nitro propane  
 Lauryl-p-chlorobenzene sulfonate  
 p-Chloroaniline  
 4,4'-Dichlorodiphenylamine  
 Di-( $\beta$ -chloroethyl) chloroacetal  
 Chloroethyl benzene  
 p,p'-Dichlorobenzhydryl  $\beta$ -chloroethyl ether  
 Bischloromethyl chlorobenzene-2,4,-disulfone  
 2-Chloro-2-nitropropyl benzyl ether

*Group C*

Benzene hexachloride (Higam 99)  
 Rotenone  
 p,p'-Dichlorobenzhydryl  $\beta$ -chloroethyl ether  
 3-Nitro-4-methoxybenzyl  $\beta$ -chloroethyl ether  
 p-Xylylene bis ( $\beta$ -chloroethyl ether)  
 1:1 mixture of p-Xylylene bis ( $\beta$ -chloroethyl ether) and Benzene hexachloride (Higam 99)

## VII: GENERAL CONCLUSION AND REMARKS

The apparatus and arrangements described form an effective and rapid method for the screening of compounds as contact insecticides for aphids. Any compound that is toxic stands out clearly.

## VIII: ACKNOWLEDGEMENTS

We gladly express our thanks to Professor A. W. Baker, in whose Department the work has been done; to Professor J. R. Scott, of the Department of Agricultural Engineering, who made the aphid rearing apparatus and the set of valves leading to the Potter Tower; and to Mrs. M. E. MacGillvray of the Field Crop Insect Laboratory, Fredericton, N.B., who confirmed our aphid identifications.

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## PRELIMINARY OBSERVATIONS ON THE USE OF THE THERMAL CONDUCTIVITY METHOD FOR THE MEASUREMENT OF METHYL BROMIDE CONCENTRATIONS IN SHIP FUMIGATION<sup>1</sup>

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### INTRODUCTION

Methyl bromide proved to be an effective fumigant for dealing with insect populations in the empty cargo spaces of ships (Monro, 1951). Subsequently, Monro, Cunningham and King (1952) studied the history of a number of ships following fumigation and demonstrated that, under a wide range of conditions, this fumigant could eradicate such populations. They also used test insects in all parts of the holds of some vessels to study the distribution of insecticidally effective gas concentrations. However, owing to the lack of a method for a continuous record, convenient under conditions of ship fumigation, no study of concentration and distribution was made by means of chemical analysis. Furthermore there was no exact knowledge of the rate of loss of fumigant during aeration of the holds, under different climatic conditions, following removal of the hatch covers.

The recent development by Phillips and Bulger (1952) of an apparatus employing the method of thermal conductivity, designed for continuous record of methyl bromide concentrations in air under field conditions, has enabled a start to be made on such a study.

### BASIC PRINCIPLE OF METHOD

When an electric current is passed through a wire the final equilibrium temperature of the wire is affected by the thermal conductivity of the gas surrounding it. If the composition of the gas is changed, its thermal conductivity will be affected and thus the equilibrium temperature of the wire will alter. This in turn will alter the resistance of the wire.

In a thermal conductivity apparatus for gas analysis the above phenomenon is used to modify a Wheatstone bridge circuit, whose two opposing arms are made up from single filaments, or groups of filaments, each in a metal or glass cell. When an electric current is passed through the filaments the whole bridge is balanced if the composition of the gases surrounding all the filaments is the same throughout. If the cells surrounding the filaments comprising one arm are then filled with a different gas mixture the bridge becomes unbalanced, and the extent of this can be measured by a galvanometer. By calibration with known concentrations of a given gas the galvanometer readings can be transposed into the units of concentration desired, such as ounces of fumigant per 1000 cubic feet.

### DESCRIPTION OF APPARATUS

A commercial model of the instrument developed by Phillips and Bulger for methyl bromide, employs four tungsten filaments in as many cells, a pair thus providing each arm of the bridge. The cells are bored in a brass block. Two cells contain the standard gas, which is air, and the other two are incorporated in the sampling train of the gas-air mixture undergoing analysis.

The commercial instrument incorporates the following essential parts:—

1. The thermal conductivity unit, as described above, Model 308 marketed by Gow-Mac Instrument Company.
2. Galvanometer (0.0 to 5.0 millivolts) with 3.2 inch scale divided into 100 divisions.
3. Gas passage for entraining samples through the cells, with inlet and outlet connections.
4. Rheostat for current control across the filaments.

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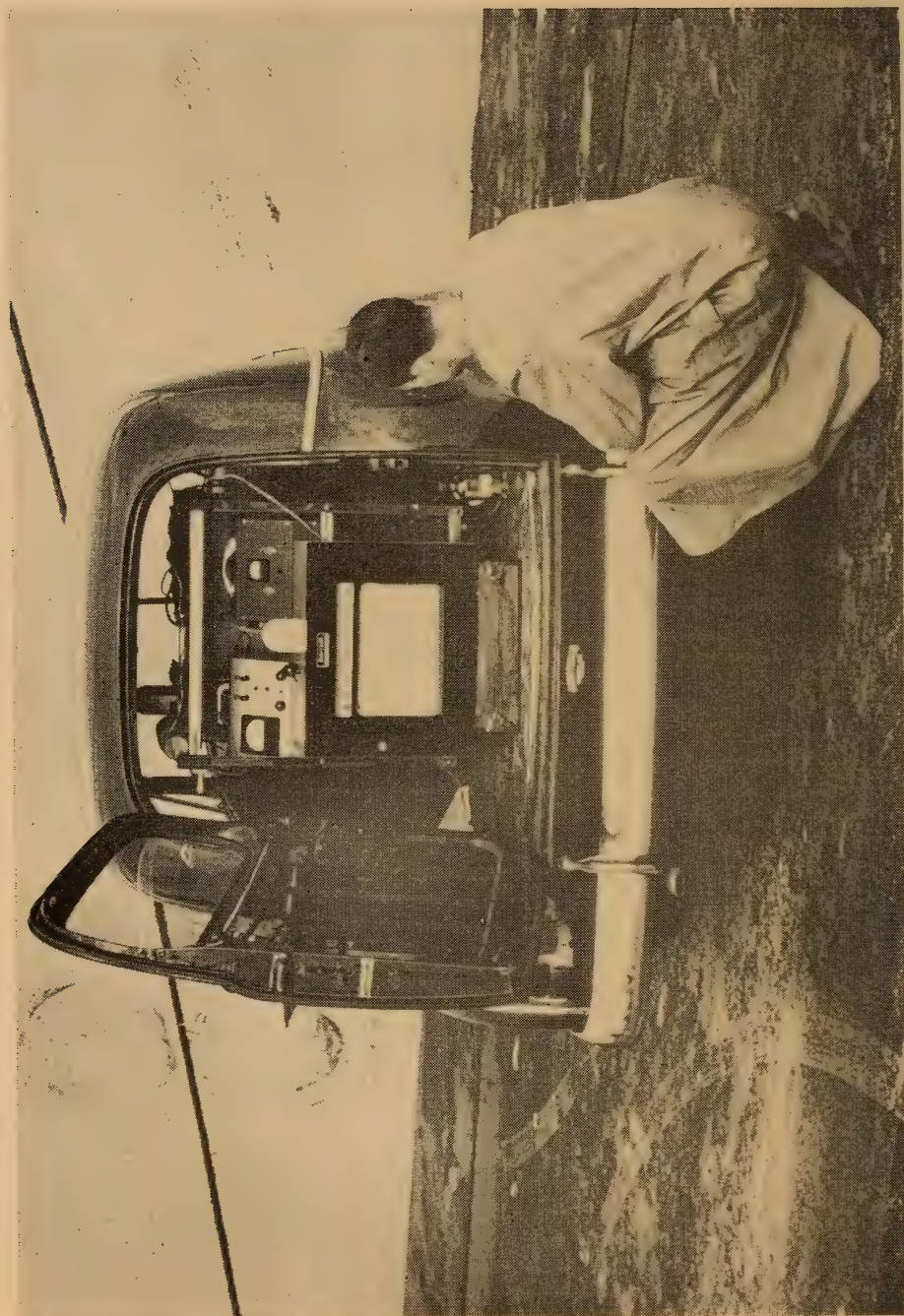


Figure 1. Gas analyser and recorder placed alongside ship.



5. Connections for direct current of 6 volts obtained from batteries or from transformer in "helper" (see below).

For facilitating operation an additional assembly, referred to as a "helper", includes the following accessories:—

6. Dryer cell for removing moisture from incoming gas-air sample.
7. Small pump.
8. Flowmeter, reading 0 to 2 cubic feet per hour.
9. Constant voltage stabiliser, with step-down transformer action.
10. Rectifier for converting alternating current to direct current.
11. Milliammeter for recording current.

## S/S KIM HOLD No 2

AUGUST 19/20, 1953.

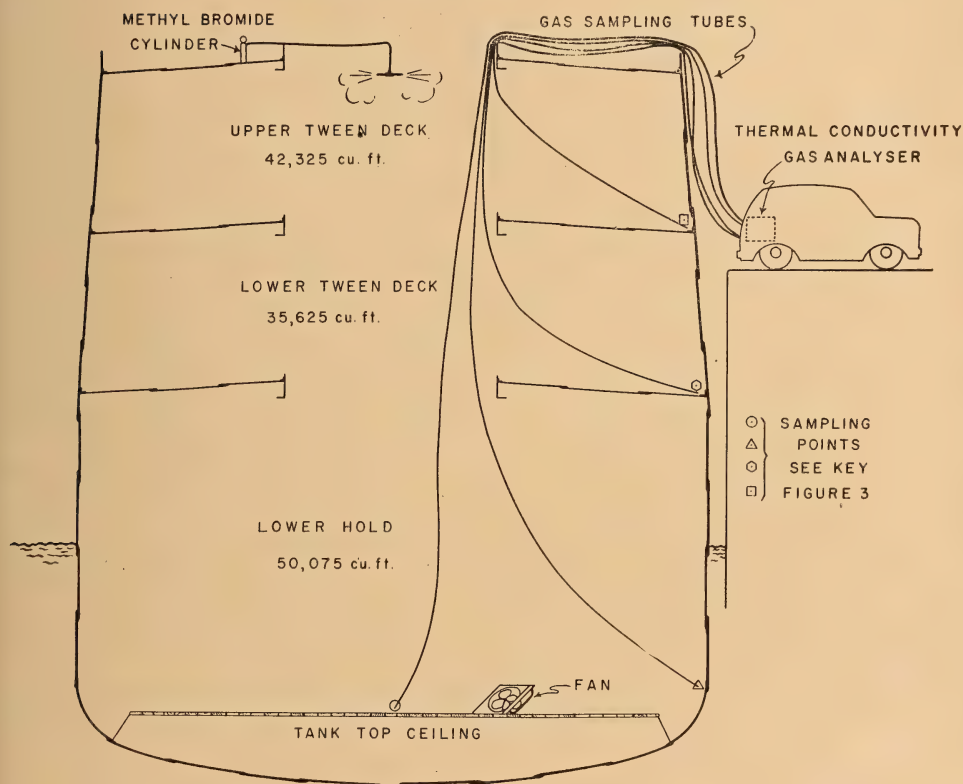


Figure 2. Diagram of gas sampling points during ship fumigation.

### ASSEMBLY OF APPARATUS FOR SHIP FUMIGATION

For the ship fumigation study the two assemblies, gas analyser and "helper", were mounted in a panel truck together with a recording potentiometer as illustrated in Figure 1. The recording instrument was connected to special leads on the analyser, and the entire apparatus was connected to 110 volt A.C. current available on the wharf.

Four sampling tubes of pliable polyethylene tubing led from four sampling points in the hold, as shown diagrammatically in Figure 2. When a sample was required from a given point

the tube from that point was fitted over the gas inlet below the dryer cell. The remaining tubes were corked until they in turn were connected. After sampling was completed from a given point the instrument was purged with fresh air before connection was made with the next sampling tube.

#### DETAILS OF FUMIGATION

The fumigation subjected to the analysis was conducted on August 19 to 20th in the harbour of Montreal on board S. S. Kim, a Norwegian vessel of 5215 tons gross registered. Hold No. 2 was selected for the analysis, and in this part of the ship there was a population of *Plodia interpunctella* (Hbn.), *Alphitobius diaperinus* (Panz.) and *Carpophilus dimidiatus* F.

In this ship there was a rather unusual construction, whereby the hatch covers were large metal plates which were put in place or removed by steel cables operated by electric winches. During the fumigation these hatch covers were covered by plastic tarpaulins and the outside opening to the ventilators were covered with canvas sheets.

#### FUMIGATION S/S KIM at MONTREAL, Que.

Aug. 19/20, 1953.

Hold No. 2.

Temp. 68° F.

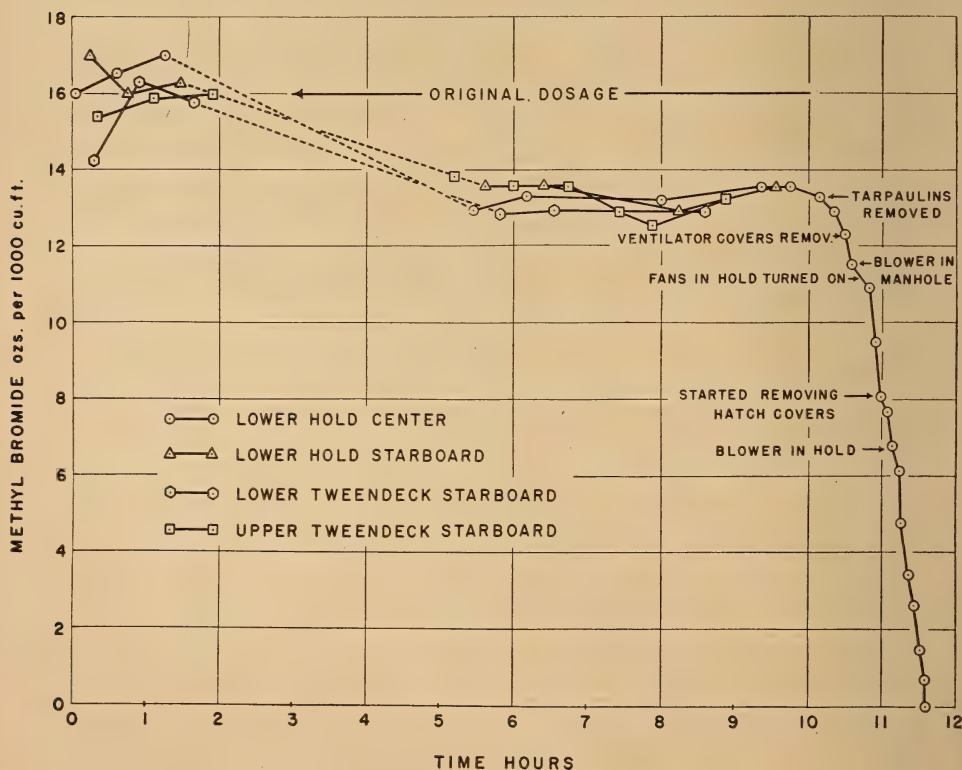


Figure 3. Concentrations of methyl bromide in different parts of hold during fumigation and ventilation.

The total capacity of the hold was 128,025 cubic feet, and 128 pounds of methyl bromide was applied at 3.20 p.m., thus giving a nominal dosage of 1 pound per thousand cubic feet. Liquid methyl bromide flowed under pressure from cylinders and entered the hold near the top.

Initial distribution of the gas was effected in the usual manner by means of a single  $\frac{1}{4}$  h.p. fan with 1725 r.p.m., placed pointing upwards at an angle of  $45^\circ$ , at the bottom of the hold on the tank top ceiling, in the position indicated in Figure 2.

This fumigation was scheduled to last for ten hours, so that the hatch covers should have been lifted at 1:20 a.m. on August 20. When the time for ventilation arrived, the member of the crew delegated to operate the electric winches was not available. It was decided to initiate ventilation by other measures, which were carried out as follows:—

- 1:29 a.m. Tarpaulins removed. Some fumigant diffused through cracks between plates.
- 1:53 a.m. Canvas covers to ventilators removed.
- 1:56 a.m. Two blowers placed in manhole to force air-gas mixture up through ventilators.
- 2:00 a.m. Circulating fans started in hold to assist ventilation.
- 2:24 a.m. Crewman arrived and removed hatch covers. Full ventilation may be considered to have commenced.
- 2:30 a.m. Two blowers placed for forcing air into hold through canvas ducts.

### RESULTS AND DISCUSSION

The results of the gas concentration analysis are set out in Figure 3.

Samples were taken at regular intervals from the four points until ventilation was begun at the time the tarpaulins were removed. It was decided to take only samples from the bottom of the hold from then on, as this was the critical place from the point of view of rapidity of ventilation.

At the conclusion of ventilation, when a zero reading was obtained at the bottom of the hold, samples were taken from the three other points and these, also, indicated that detectable concentrations had disappeared.

As might be expected, during the first two hours of fumigation the readings were somewhat scattered. Between the second and fifth hours the operators of the equipment were absent and readings were resumed after 5 hours and continued until aeration was completed.

After six hours the concentrations throughout the structure had fallen below the nominal dosage. A suggestion of increase in concentration from the eighth to the tenth hours is explained by the fact that when the gas analyser is operated continuously it has been observed to exhibit a slight upward "creep". This creep is believed to be due to a gradual increase in temperature of the entire cell block of the thermal conductivity unit, caused by the heat from the filaments.

### CONCLUSIONS

This preliminary trial has indicated the usefulness of the thermal conductivity method for studying gas concentrations during ship fumigation. The assembly of gas analyser, "helper", and recording potentiometer is adaptable for this purpose.

Despite the unusual construction of the hatch coverings in this particular ship, it may be concluded that during this fumigation the conditions affected by the hatch and its sealing were typical of those obtaining during normal treatments. This is substantiated by the fact that removal of the tarpaulins at ventilation time led immediately to a rapid fall in concentration within the hold.

It is shown that during the fumigation of a ship of good construction the methyl bromide concentration is held at a high level throughout the treatment. After further studies of this nature are made data will be available for comparison with the results of laboratory studies on the concentration  $\times$  time factors required to control the various insect pests found in the holds of ships.



Although the usual ventilation procedure was delayed, and the hatch covers were not taken off at the beginning of ventilation, dissipation of the gas was rapid. All detectable concentrations had disappeared within 90 minutes of the removal of the tarpaulins, the first step in the ventilation process.

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### NOTES ON THE LIFE-HISTORY, HABITS, AND CONTROL OF THE APPLE SEED CHALCID, *TORYMUS DRUPARUM* BOH. (HYMENOPTERA:CHALCIDIDAE)<sup>1</sup>

H. P. RICHARDSON<sup>2</sup> and W. R. ALLEN<sup>3</sup>

The apple seed chalcid, *Torymus druparum* Boh., was discovered by C. R. Crosby, Cornell University, Ithaca, N. Y., in the eastern United States in 1906; the date of its introduction is unknown but it was probably introduced from Europe by early colonists who brought apples to America and planted the seeds (Cushman, 1916).

At the Canada Experimental Station at Morden, hardy varieties of crabapples and apples are being developed for the prairie region. In 1944, the production of apple and crabapple seed for this purpose at the Station was reduced by an estimated 50 per cent. This loss was primarily responsible for the initiation in 1945 of a study on the life-history, habits, and control of the insect in anitoba.

#### LIFE-HISTORY, HABITS, AND DAMAGE

In Europe, the chalcid has been reared from seeds of *Sorbus intermedia* (Ehrh.) Pers. [*S. scandia*], *S. aria* (L.) Crantz, *Malus baccata* (L.) Borkh., and *M. sylvestris* Mill.; Crosby listed as hosts the Lady apple; the wild crabapple, *M. coronaria* (L.) Mill.; and the following cultivated crabapples: a form of *M. baccata*, [*M. sibirica* var. *striata*], *M. floribunda* Van Houtte, *M. prunifolia* (Willd.) Borkh., *M. ioensis* (Wood) Brit., and *Sorbus aria* × *S. torminalis* [*S. latifolia* (Lam.) Pers.] (Cushman, 1916). Cushman reported also that other American workers found larvae of the chalcid in Northern Spy, Baldwin, Fameuse, Wagener, Russet, Tolman Sweet, and Lady apples.

In Manitoba, the chalcid was reared from crabapple and apple selections of the crosses *M. baccata* × *M. pumila* Mill. and *M. pumila* var. *niedzwetskyana* (Dieck) Schneid. × *M. baccata*, from pear selection of the cross *Pyrus communis* L. × *P. ussuriensis* Maxim., and from a European mountain ash, *Sorbus aucuparia* L. Cushman (1916) considered the small-fruited wild seedling of the apple to be the natural host of the chalcid. In Manitoba, the crabapple is the main host. The apple and the pear are not particularly suitable hosts because their greater

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size usually prevents the ovipositor of the chalcid from reaching the seeds. The mountain ash was only lightly infested and the adults reared from it were smaller than those from crabapples, apples, or pears.

The chalcid overwinters as a larva in the seed and pupates about the end of May. The pupal stage lasts 17 to 19 days; for the first 12 days the pupa remains uncoloured, then assumes the bright green of the adult. The adults commence emerging about June 18 and continue to emerge for about 3 weeks. In experiments, female chalcids provided with granular sugar and water survived 19 to 32 days, the average life being 25.8 days; the males lived about half as long. The preoviposition period ranged from 2 to 4 days, and the female chalcids freely oviposited in crabapples placed in the cages.

In ovipositing, the female chalcid appears to probe the surface of the fruit with its antennae until a suitable spot is found, usually a depression. It then raises its abdomen, frees the ovipositor of its sheath, places the tip against the skin of the apple, and with a swaying motion of the raised abdomen forces the ovipositor into the apple, depositing an egg in a seed. The process usually requires several minutes.

The wound caused in the fruit by the ovipositor appears as a brown streak in the flesh from the apple skin to the seed coat. When the infestation is severe, repeated oviposition causes distortion of the fruit. Only one larva develops per seed, although the oviposition marks show that more than one egg may be laid in a seed.

Cusham (1916) observed that some of the chalcids remain in larval diapause over two winters in the eastern United States. To determine whether the same phenomenon occurs in Manitoba, 370 infested crabapple seeds were examined after chalcid emergence had ceased. Of these, 79.7 per cent contained larvae, 48.6 per cent of which were alive; 4.7 per cent contained dead pupae; and 15.9 per cent had emergence holes. Furthermore, infested crabapples from which 59 chalcids emerged in 1946 yielded several adults in 1947, thus demonstrating that some of the larvae remain in diapause for two winters in Manitoba.

#### CHEMICAL CONTROL

In preliminary tests, plots comprising sections of a row of edible and a row of ornamental crabapple seedlings were sprayed at the start of chalcid emergence with DDT in 1945 and with DDT and chlordane in 1948. The treatments were replicated four times in 1945 and twice in 1948. Each insecticide was applied at 1 lb. of toxicant per 100 gal. of water with spray guns at a pressure of 400 lb. per square inch. In 1945 samples consisted of about 300 crabapples from each of the ornamental and edible varieties in each plot. Each sample was run through an apple

Table I

Average percentage of seeds of edible and of ornamental crabapples infested by the apple seed chalcid after treatment with DDT and chlordane at 1 lb. per 100 gal., 1945 and 1948

Insecticide	Plot	Average percentage of seeds infested	
		1945*	1948**
DDT	Edible crabapple	3.9	15.3
	Ornamental crabapple	4.6	10.9
Chlordane	Edible crabapple	—	41.8
	Ornamental crabapple	—	83.4
Check	Edible crabapple	28.5	69.2
	Ornamental crabapple	10.3	53.3

\* Four replicates.

\*\* Two replicates.

crusher and the seeds were extracted from the pulp by washing and flotation. Three hundred seeds of each sample were opened and the infestation was recorded. In 1948, 100 crabapples were taken at random from each plot, the seeds being examined and the infestation recorded.

From 1949 to 1952, DDT was applied near the start of chalcid emergence to a 75-ac. mixed planting of apple, crabapple, other fruits trees, and ornamentals. Samples were taken from plots of 2 to 3 trees each of the crabapple varieties Dolgo and Alexis. The fruit of these varieties is very susceptible to chalcid attack (Table II). The control plot, of the crabapple species *M. prunifolia*, was in a separate planting half a mile distant. A spray was applied at three-quarters of a pound of DDT per 100 gal. of water. A sample of 100 crabapples was taken from each plot, the seeds being examined and the infestation recorded as in 1948.

The preliminary tests (Table I) showed that DDT reduced the chalcid infestation but that chlordane was of little value.

The application of DDT to the apple and crabapple orchards from 1949 to 1952 (Table II) showed that in each of the four years DDT was very effective. The high level of infestation of 1948 was reduced to a low level.

Table II

Percentages of seeds of crabapples infested by the apple seed chalcid after treatment with DDT at  $\frac{3}{4}$  lb. per 100 gal. of water, 1949 to 1952

Plot	Variety	Percentage of seeds infested*				
		Unsprayed 1948	1949	1950	Sprayed 1951	1952
1	Alexis	86.6	8.7	0.0	0.0	13.3
2	Dolgo	—	5.5	3.5	0.3	1.9
3	Dolgo	85.6	2.1	10.2	0.8	0.0
4	Dolgo	—	31.1	32.7	2.4	5.0
5	Dolgo	88.7	35.2	15.6	1.1	3.1
6	Alexis	—	28.6	12.5	1.2	9.1
7	Dolgo	91.1	77.0	36.6	0.0	—
8	Dolgo	93.8	72.5	1.1	1.2	29.2
9	Dolgo	—	58.9	3.0	1.2	8.6
Check	<i>M. prunifolia</i>	—	92.5	64.3	92.1	59.2

\* Sample: 100 crabapples from each plot.

The importance of timing the application of DDT to coincide with the start of emergence of the chalcid was demonstrated particularly in the 1949 experiments (Table II). In that year the marked decrease in the percentage of infested seeds in plots 1–3, sprayed on June 23, in comparison with plots 4–6 and 7–8, sprayed on June 27 and 28 respectively, was directly related to the time of spraying. As oviposition was observed on June 23, plots 4–9 must have been sprayed well after emergence had started. The variations in the percentages of infested seeds in 1950 and 1952 may be accounted for in part by prolonged chalcid emergence caused by cold, wet weather in 1950, and to a four-day delay in commencement of application in 1952. The small size of the insect makes it difficult for growers to use emergence as a means of timing; furthermore, it has not been possible to relate emergence with any phenological phenomena. For these reasons the recommended date of spraying in southern Manitoba, June 18, has been arbitrarily based on records of emergence for 1945–46 and 1948–53. In six of these eight years, emergence began on June 17 to 19; in 1946 and 1952 it commenced on June 11 and 7 respectively. As the pre-oviposition period is about three days, it is evident that June 18 would usually be satisfactory as the date to commence spraying in Manitoba.



## SUMMARY

The apple seed chalcid, an important factor in the production of seed for the development of new varieties of stock of apples and crabapples for the prairie region of Canada, overwinters as a larva in the seed and pupates about the end of May. The adults generally emerge from June 17 to 19. Some of the insects spend two winters in the larval stage.

In southern Manitoba, the chalcid may be controlled with one application of DDT, at three quarters of a pound per 100 gal. of water, on June 18.

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RESIDUAL CONTROL OF WIREWORMS IN FLUE-CURED TOBACCO<sup>1</sup>

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At the Chatham laboratory, BHC was first tested for the control of wireworms in 1947; Armand (1), experimenting on potatoes, tomatoes, corn, and onions, obtained promising results with approximately 4 oz. of the gamma isomer per acre. The material was effective when incorporated into the soil, either as a spray or mixed with granular fertilizer. In the same year, D. S. Marshall, then at the Chatham laboratory, obtained satisfactory control of wireworms in flue-cured tobacco by incorporating BHC into the soil as a dust, or combined with granular fertilizer.

Previous to the introduction of BHC, it was not unusual to replant entire fields of flue-cured tobacco twice or even three times. Since 1947, BHC incorporated into the soil has been one of the accepted measures for wireworm control in southwestern Ontario.

In 1948, G. E. Coppel, then in charge of wireworm investigations at Chatham, commenced an experiment to study the residual effect of BHC on the wireworm population in a flue-cured tobacco field. A randomized plot experiment begun in the same year was designed to test BHC, chlordane, DDT, ethylene dibromide, and DD mixture for the control of wireworms in fields used for flue-cured tobacco production. Both experiments were conducted in Fox sandy loam in Elgin County near Port Stanley, Ontario, where the eastern field wireworm, *Limonijs agonus* (Say), is the most important economic species. This paper is based on the results of wireworm population counts made in the two treated areas from 1948 to 1953, inclusive.

## METHODS AND MATERIALS

In the usual rotation practised by flue-cured tobacco growers in this area, tobacco land is sown to rye after the tobacco has been harvested. This crop of rye is harvested late the following year and a second, or volunteer, crop is allowed to start from the seed shattered during harvest. This volunteer rye is ploughed under in the spring as green manure for the next crop of tobacco. The usual tobacco-rye rotation was followed in the plot experiment, but not in the field study.

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In both experiments, the insecticides were applied before transplanting the tobacco. The plants were set in rows 36 to 42 inches apart and spaced at intervals of approximately 24 inches.

The treatments were evaluated by larval population counts made by sifting 1-foot cubes of soil through a quarter-inch screen. Approximately 20 samples were taken in the experimental field each year; 5 samples were taken from each plot in the plot experiment. The samples were taken at random in the crop row during the years that the experimental areas were planted to tobacco or corn, and at random throughout when the areas were planted to rye or oats. Counts made in rye or oats are not comparable with those made in rows of tobacco or corn; the wireworm population in tobacco and corn is concentrated in the rows, whereas in the cereals they are dispersed rather evenly.<sup>3</sup>

*Field Experiment.*—BHC, 50 per cent wettable powder (6 per cent gamma isomer), was mixed with granular fertilizer at 3.84 oz. of gamma isomer per 100 lb. of fertilizer per acre. This was drilled into the soil on June 4, 1948, in rows 7 inches apart, to a depth of 4 to 6 inches by means of a fertilizer drill.

In 1948, the wireworm population was counted before treatment in May, and after treatment in July and August. From 1949 to 1953, counts were made yearly in July.

*Plot Experiment.*—This experiment was conducted on duplicate plots 40 x 80 feet. The following materials and rates per acre were used for the control of the wireworms: BHC, 2 lb. (3.84 oz. gamma isomer); chlordane, 1 lb.; DDT, 1 lb.; ethylene dibromide, 20 per cent by volume, 10 gal.; and DD mixture, 200 lb. BHC, chlordane, and DDT were dusted on the soil surface and worked in by hand raking to a depth of approximately 2 to 3 inches. Ethylene dibromide and DD mixture were injected approximately 8 inches into the soil with a calibrated soil injector.

Counts were made in the plots in July of each year.

## RESULTS AND DISCUSSION

*Field Experiment.*—Table 1 shows that the BHC treatment reduced the wireworm population from 1948 to 1950. Since 1950, the population has not increased materially. Re-infestation may have been prevented by the residual effect of the BHC, and as a result of the general use of BHC from 1948 to 1950, on nearly all of the cultivated land in the immediate district.

TABLE 1

AVERAGE NUMBERS OF WIREWORMS PER SOIL SAMPLE FROM 1948 TO 1953  
IN THE EXPERIMENTAL FIELD TREATED WITH BHC\* IN  
JUNE, 1948, PORT STANLEY, ONTARIO

<i>Time of Sampling</i>	<i>Crop</i>	<i>Wireworms per sample of 1 cu. ft.</i>
May, 1948 (before treatment)	Fallow	7.60
July, 1948 (after treatment)	Tobacco	4.16
August, 1948	Tobacco	2.58
July, 1949	Tobacco	1.92
July, 1950	Oats	0.05**
July, 1951	Tobacco	0.20
July, 1952	Corn	0.25
July, 1953	Tobacco	0.30

<sup>3</sup> Ratio of wireworm population in rye to that in tobacco was 1:1.76.

\* 50 % wettable powder, 6% gamma isomer, Canadian Industries Ltd., Montreal, Que.

\*\* Not directly comparable because of cropping practice; possibly equivalent to 0.09 wireworms per sample in the tobacco row.

Wireworm damage to tobacco grown in the field has been negligible since 1948. The 1953 population of 0.30 wireworms per sample represents 1 to 2 wireworms per tobacco plant; therefore, even this low population could cause severe damage in a year favourable to wireworm feeding.

*Plot Experiment.*—Only BHC was effective in lowering the wireworm population in the plot experiment from 1948 to 1953. The action of the BHC was not affected when it was incorporated into the soil to a depth of approximately 2 to 3 inches. The wireworm population in the plot area, however, was considerably lower than in the field experiment.

TABLE 2

AVERAGE NUMBERS OF WIREWORMS PER SOIL SAMPLE OF 1 CU. FT. FROM 1948 TO 1953 IN THE PLOT EXPERIMENT AFTER APPLICATION OF VARIOUS INSECTICIDES IN 1948, PORT STANLEY, ONTARIO

<i>Treatment per acre</i>	<i>Tobacco Crop</i>				<i>Rye Crop</i>			
	1948	1950	1952	<i>Geometric difference between means of transformed values<sup>1</sup> 1952-1948</i>	1949	1951	1953	<i>Geometric difference between means of transformed values<sup>1</sup> 1953-1949</i>
BHC <sup>2</sup> , 2 lb. (3.84 oz. gamma isomer)	1.4	1.0	0.2	-0.326	0.6	0.3	0.2	-0.287
DD mixture <sup>3</sup> , 200 lb.	0.2	1.0	0.4	0.108	0.0	1.4	0.9	0.690
Ethylene dibromide <sup>4</sup> , 10 gal.	0.1	1.0	0.7	0.321	0.2	0.7	0.7	0.389
Chlordane <sup>5</sup> , 1 lb.	3.3	2.0	1.8	-0.201	0.3	0.7	0.5	0.151
PDT <sup>6</sup> , 1 lb.	2.6	5.3	5.0	0.309	1.8	3.3	1.7	-0.036
Check	2.5	4.0	2.4	0.067	1.0	1.6	2.6	0.331
Difference necessary for significance at 5% level				0.345				0.372

<sup>1</sup>The transformation  $y = \log(x+1)$ , where  $x$  is the number of wireworms counted, was used.

<sup>2</sup>50% wettable powder, 6% gamma isomer, Green Cross Insecticides, Montreal, Que.

<sup>3</sup>Shell Oil Co. of Canada Ltd., Toronto, Ont.

<sup>4</sup>Dowfume W40, The Dow Chemical Co., Midland, Mich.

<sup>5</sup>Dowchlor 40W, The Dow Chemical Co., Midland, Mich.

<sup>6</sup>50% wettable powder, Canadian Industries Ltd., Montreal, Que.

Ethylene dibromide and DD mixture were effective in lowering the wireworm population in the year of treatment and the year following. As these treatments have no residual action, population increases began in the second year after treatment; and from 1950 to 1953 the wireworms were sufficiently numerous to constitute a serious threat to row crops, but probably not to cereals.

The population reduction from the chlordane treatment was unsatisfactory. The rate, however, was only one-sixth of that now recommended.

DDT at 1 lb. per acre gave no reduction in the wireworm population. This is not remarkable since, in other experiments conducted from the Chatham laboratory, 10 lb. of DDT per acre failed to give satisfactory control of the eastern field wireworm.



The adults of the eastern field wireworm can fly, but re-infestation in the experimental area has probably been slowed by the reduction of the wireworm population in the adjacent fields. The remainder of the field in which the experiment was conducted was treated with BHC in 1948, and the fields alongside in 1949.

### CONCLUSIONS

Experimental work conducted from 1948 to 1953 showed that BHC worked into the soil at 3.84 oz. of gamma isomer per acre, satisfactorily controlled the eastern field wireworm, *Limonijs agonus* (Say), for 5 years in a tobacco-rye rotation in Fox sandy loam. Wireworm injury to flue-cured tobacco grown in the treated soil was negligible from 1948 to 1953. Chemical analyses of treated soil in England (2) and the United States (3) confirms this residual property of BHC. Stone and Foley (4) found that BHC was effective against wireworms for 3 years. In an experiment at the Chatham laboratory, BHC at 12 oz. of the gamma isomer per acre, however, was effective for only one year in protecting potatoes in Berrien sandy loam.

Ethylene dibromide and DD mixture satisfactorily reduced the wireworm population in the year of application. Since these materials have little residual action, some re-infestation has occurred since 1949. The rate of re-infestation was reduced by the general treatment of cultivated land in this area with BHC.

Chlordane at 1 lb. per acre, although reducing the wireworm population slightly, was unsatisfactory because practical elimination of the wireworm is necessary for crop protection in widely spaced susceptible crops like tobacco. This was expected as the application was considerably lower than the present recommended rate.

DDT at 1 lb. per acre appears to have had little or no effect on the wireworm population.

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## OVERWINTERING HABITATS OF THE ONION THRIPS, *THRIPS TABACI* LIND. (THYSANOPTERA: THIRIPIDAE), IN SOUTHWESTERN ONTARIO<sup>1</sup>

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The onion thrips, *Thrips tabaci* Lind., is one of the most serious insect pests in the onion-growing marshlands of southwestern Ontario. The species reproduces rapidly and feeds heavily on the succulent leaves of onions grown from seed, sets, or seedlings. Infestations begin about

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mid June and the populations remain at a high level from late June until harvest, usually in late August and September. Infestations are initiated by dispersing adults moving in from nearby crops. Observant growers have reported population increases in onions after adjacent hay crops had been cut and, conversely, fewer thrips in onions when adjacent hay crops were left standing. The suitability of nearby crops as overwintering habitats is also a factor in infestation. This is a report on investigations in 1952 and 1953 on the relative importance of various overwintering habitats of the onion thrips in southwestern Ontario and of the proximity of various crops to onions.

#### METHODS AND EQUIPMENT

With the exception of July, 1953, two samples from each of eight study fields were taken every two weeks from November, 1952, to December, 1953. In the winter, a sample consisted of the green crowns of plants and of soil from an area 7 by 7 inches to a depth of half an inch. Because of the mild, dry winter of 1952-53, the soil in all samples was less moist than in years when precipitation was normal. Beginning in April when the new growth started, the samples consisted of plants that were 3 to 4 inches high.

The equipment used to obtain the thrips from the samples was a modification of the Berlese funnel and was very similar to what employed by Shirck (2) in Idaho. As the sample was brought from the field, it was placed in a 6-inch flower pot. A waterproof card-board container 5 inches high, with the bottom removed, was taped to the top of the flower pot. The lid of the container was replaced with muslin to allow aeration of the sample, and to prevent escape of specimens. To the bottom of the pot was cemented a rubber stopper, with a hole in line with the drainage hole. A small jar containing 20 cc. of 5 per cent formalin was fitted to the rubber stopper. Ten of these collecting units were held in a rack in a drying oven.

The drying oven (Fig. 1), 5 feet long by 3 feet high by 1¼ feet wide, was constructed of one-quarter-inch plywood and lined with half-inch insulating board. Two swinging doors were constructed on one side of the oven and a small glass window was inserted in one of them for recording temperatures. Heat for the oven was supplied by three 100-watt bulbs and was circulated by an electric fan immediately below the bulbs and facing upward. The temperature in the oven was thermostatically controlled at 110°F.

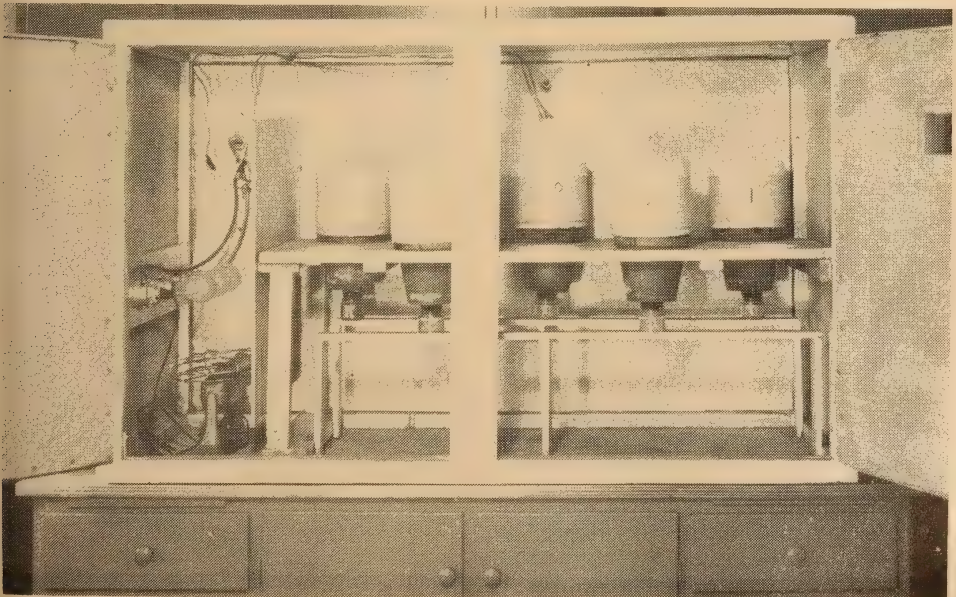


Fig. 1. Drying oven with collecting units.

As the samples dried, the thrips moved downward and eventually into the formalin. Seven days in the drying oven were sufficient to remove the thrips from the samples. The formalin was then filtered in a Beuchner vacuum funnel and the thrips and other specimens were left exposed on a filter paper, where they were identified and counted.

Adults of *T. tabaci* were identified from Hinds (1).

The study fields, described below, were within a quarter of a mile from an 11-acre onion field that had been severely infested by thrips in 1952 and 1953.

*Red Clover.*—A dense stand of red clover was grown on a 10-acre field adjacent to the onions. On May 21, the field was ploughed and corn planted.

*Alfalfa A.*—Alfalfa was grown in 1952 and 1953 on a 12-acre field separated from the onions by 50 yards of corn stubble.

*Winter Wheat.*—A 6-acre field of winter wheat, adjacent to the onion field, was planted in the fall of 1951, ploughed under as a green manure crop on May 6, 1952, and planted to field beans. It was re-seeded to winter wheat in September, 1953.

*Alfalfa B.*—The stand in this 4-acre field was less dense than that of alfalfa A. It was separated from the onion field by a field of red clover, a quarter of a mile wide. It was ploughed on May 21, and planted to corn.

*Grass Sod.*—The samples were obtained from the banks of a drainage ditch that bordered the field on one side. They consisted of the crowns of species of meadow grasses and weeds that grew profusely during the summer. Matted, decaying vegetation was also included.

*Oat Stubble.*—No crop of leguminous hay or green manure had been planted with the oats in this 15-acre field in April, 1952. Following harvest in late June, 1952, the field lay dormant until May 21, 1953, when it was ploughed and corn planted. All samples taken from this field included oat stubble, which was approximately 6 inches high.

*Onion Culls.*—Practically every farm on the marsh has an onion cull pile. This includes discarded bulbs and dried onion leaves that are pulled from the onion bulbs during the "topping" operation. Because of their proximity to the onion fields, the cull piles have always been considered a source of thrips infestation. A sample consisted of a 6-inch flower pot filled with three bulbs and with dried leaves.

*Muck Soil.*—Samples were taken directly from the field in which the onions were grown. A sample consisted of the soil from an area 7 by 7 inches to a depth of 2 inches.

## RESULTS AND DISCUSSION

Neither adults nor nymphs were obtained from the onion cull pile or the muck soil. The results of 13 months' collections are given in Table 1.

As the systematics of the immature stages of thrips is poorly known, the figure given in Table 1 for the number of nymphs represents the total of all species present in the sample.

The onion thrips overwintered principally in the adult stage, and was particularly abundant in fields of red clover and alfalfa. After the onion harvest in September, the thrips population dispersed to the nearest suitable overwintering site. This is well illustrated in a comparison of the numbers taken in the two alfalfa fields. The alfalfa A field, which was only 50 yards from the onion field, supported a large overwintering population, whereas the population in the alfalfa B field, a quarter of a mile away, was negligible. The red clover and alfalfa A fields were harvested on May 22 and June 20, respectively, and by June 22 the infestation of the thrips in the adjacent onion field was of such severity as to warrant control measures.





The nymphal and adult thrips populations were at a minimum in January and February, and began to increase during March and April. In May, the nymphal population in the red clover, alfalfa A, and wheat fields increased markedly; an increase was also apparent in grass sod.

Grass sod bordering onion fields, onion culls, and muck soil do not appear suitable as overwintering habitats and are, therefore, not considered a source of thrips infestation. The oat stubble field was a potential source of infestation, as indicated by the numbers taken in November and December, 1952.

The results of this study are remarkably similar to those obtained by Shirck (3) in southern Idaho.

#### SUMMARY

A technique is described for obtaining the onion thrips from soil and vegetation. Apparatus is described and illustrated. Of eight sampling sites, red clover and alfalfa fields harboured the largest thrips populations. Grass sod, onion culls, and muck soil were not important overwintering habitats of the thrips. Overwintering habitats that were adjacent to or near, the onion field supported greater thrips populations than a similar overwintering habitat a quarter of a mile from the onion field. Onions became infested when nearby hay crops were cut in June. In the absence of alfalfa and clover fields, oat stubble and winter wheat would probably provide suitable overwintering habitats.

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## HISTOLOGY OF THE EYES AND THEIR CONNECTION WITH THE BRAIN IN THE DAMSEL-FLY, *Lestes rectangularis* Say (ODONATA: LESTIDAE)

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#### MATERIAL AND METHODS

The insects used in this study were adult damsel-flies, *Lestes rectangularis* Say, captured on June 19, 1950 around the borders of the Dundas Marsh, Hamilton, Ontario where this species occurs in flight during June and July (Judd, 1953). They were killed in a poison jar and immediately after death they were slit open along the mid-dorsal line of the thorax and abdomen and placed in Bouin's fixative for about twelve hours. The heads were then removed and sectioned at 10 microns and the sections were stained with either Mallory's triple stain or Delafield's haematoxylin and eosin. Drawings were made with India ink on Bristol board to illustrate features of the histology of the eyes. A rayoscope was used to project the outlines of the tissues on the drawing board and finer details were added by examination under a compound microscope with the aid of a calibrated ocular micrometer.

In describing the characters of the head of the Odonata, Liu (1933) distinguished the damselflies of the family Lestidae by noting that "the postocular lobe is better developed, the dorsal half of the eye is pushed outward, and the inner eye margins are not parallel with each other." These features are noticeable in the head of *Lestes rectangularis* (Fig. 1), for the postocular lobes (PL) are prominent and the inner margins of the compound eyes diverge posteriorly. The compound eyes (E) bulge from the sides of the head and the lateral and median ocelli (LO, MO) form the corners of a triangle in the centre of the head structure, the lateral ocelli extending upward above the level of the median eye. Liu (1933) also made comparative measurements of the external features of the head in five genera of Lestidae, e.g. the width and length, and showed that if the average width is expressed as 10, the average length is represented by 4.4. In *Lestes rectangularis* the width of the head is 5 mm. (Fig. 1) and the length 2.3 mm. If the width is expressed as 10 the length is represented by 4.6, this figure approximating the average figure for length (4.4) as stated by Liu.

#### DESCRIPTION

In horizontal and vertical sections of the head (Figs. 2, 3) the compound eyes (E) are seen to occupy the whole of the outer ends of the sections, being composed of ommatidia radiating outward from the ganglia of the brain. The brain (B) is narrow and transversely elongated and straddles the oesophagus (Oe). The lateral ganglionic extensions of the brain are the opticon (OP), followed by the epipticon (EOP) and the periopticon (POP). These structures and the rest of the brain tissue are enveloped in the nerve cell sheath (NCS). The optic nerve (Fig. 4 — ON), leaving the brain tissue proper, widens out to meet the opticon which consists of long narrow cells, the nuclei of which form a regular row across the middle of the tissue. The opticon is connected to the epipticon by the fibres of the inner chiasma (IC). The epipticon forms a cup-like mass enveloping the outer end of the opticon, and as in this latter structure, consists of long, narrow cells with nuclei centrally placed. The fibres of the outer chiasma (OC) cross one another in traversing the space between the epipticon and periopticon and are closely surrounded by the cellular mass of the nerve cell sheath (NCS). Beyond the outer end of the cells of the periopticon are the ommatidia (O) of the compound eye.

The band of tissue lying between the outer end of the periopticon and the basement membrane below the ommatidia has been called the "terminal anastomosis" by Hickson (1885) (Fig. 6 — TA1-TA4). The periopticon (POP) is composed of long cells in which the nuclei are mainly concentrated toward the outer ends. Adjacent to the outer border of the periopticon is the inner region of the terminal anastomosis (TA1) which consists of numerous cell bodies with spherical nuclei, a region called the "äussere Körnerschicht" by Hertweck (1931). In the next region (TA2) the fibrils are collected into bundles which are separated by intervening tracheae (T). These tracheae form a regular row across the tissue of the terminal anastomosis parallel to the basement membrane (BM). The third region of the terminal anastomosis (TA3) is one of plexus formation, containing numerous cell bodies. In the fourth region (TA4) the fibrils are again arranged in bundles and pass through interstices in the basement membrane to the ommatidia.

The ommatidia of the compound eye are about 0.5 mm. long (Fig. 5) at the middle of the eye and are progressively shorter toward the periphery where they are about half that length. At the outer end of an ommatidium is a biconvex facet of the cornea (C). Behind this is the crystalline cone (CC), its broad outer end containing four flattened Semper's nuclei (SN). Having the Semper's nuclei at the outer end of the crystalline cone, the ommatidium is thus of the "eucone" type (Hickson, 1885). Adjacent to the narrow end of the crystalline cone are the nuclei of the accessory pigment cells (APC) followed by the larger principal pigment cells (PPC). The retinal region of the ommatidium is about 0.4 mm. long and consists of eight retinal cells surrounding the central rhabdom (R). The nuclei of the retinal cells are arranged in three groups which form three distinct rows across the width of the rank of ommatidia in the eye. The first group is at the outer end of the retinal cells and consists of two nuclei (RN1, RN2). The second group comprises four nuclei (RN3, 4, 5, 6) clustered at about one-third of the distance along the length of the retinal cells. The third group,



comprising nuclei RN7 and RN8, is about 0.1 mm. from the basement membrane. On the outer surface of the retinal cells are small nuclei (PCN) of the retinal pigment cells. Between the ommatidia are thin-walled tracheal sacs (T) with a few large, scattered nuclei (TN). A tangential section of the outer ends of the ommatidia (Fig. 7) reveals the hexagonal facets of the cornea (C), the Semper's nuclei in clusters of four (SN) and the crystalline cones (CC) showing the outlines of the four cells from which each was formed.

Oguma (1917), in his investigation of the histology of the eyes of dragon-flies in the two genera *Somatoclora* and *Sympetrum*, found that the dorsal ommatidia were larger than the ventral ommatidia and that they exhibited several differences in structure. Liu (1933) computed the ratio of size of the larger (dorsal) facets and the smaller (ventral) facets in the eyes of dragon-flies and damselflies of the various families of Odonata. The average ratio was largest in the Gomphinae (2.68) and Libellulinae (2.12) and least in the Zygoptera (1.31). In *Lestes uncalus*, as representing the Lestidae, the ratio was small, (1.1). In the species at present under consideration, *Lestes rectangularis*, no difference in the size of the facets was detectable as between dorsal and ventral facets, but the facets of the outer bulge of the eye were slightly larger than those adjacent to the periphery of the eye.

The ocelli of *Lestes rectangularis* are arranged in a triangular pattern in the middle of the upper surface of the head (Fig. 1), the median ocellus (MO) being farther forward than the two lateral ocelli (LO). The lateral ocelli are raised above the general surface of the head on two short stalks (Figs. 11, 12). The cuticle of the head (CU) around the bases of the stalks and between them is heavily sclerotized and is marked externally by rough projections. A median section of a lateral ocellus (Fig. 11) shows the cuticle expanded into an almost spherical corneal lens (C). The hypodermis (H) is differentiated into a layer of corneagenous cells (CG). Next to this is an inner, thicker layer of retinal cells (RT). Beneath the retinal cells the lateral ocellar nerves (LON) pass downward to the brain (B) and straddle the median ocellar nerve (MON) which passes backward between them (Fig. 12). This passage of the median ocellar nerve between and below the lateral ocellar nerves has been noted by Baldus (1924).

The median ocellus at its greatest width is about 0.3 mm. wide (Fig. 10). A section across this width reveals the large, convex lens (C) continuous with the surrounding cuticle. Below this is a layer of corneagenous cells (CG) which are largest toward the periphery of the layer. The retinal layer (RT) consists of numerous elongated cells, each with a central dark rhabdom. Sections of the median ocellus ventral to its greatest width show the tissue of the ocellus organized into two similar portions, bilaterally arranged (Figs. 8, 9). The two portions are covered by a continuous cornea (C) and the division into two is not evident externally. Each of these portions comprises elements of the layer of corneagenous cells (CG) and of the retinal layer (RT) and each contributes a separate element to the median ocellar nerve (MON) which passes backward into the brain (B). This division of the median ocellus in insects into two portions has been noted by Snodgrass (1926) and is the basis for his conclusion that "there is evidence in the structure and development of the median eye that it is the product of fusion of an original pair of eyes."

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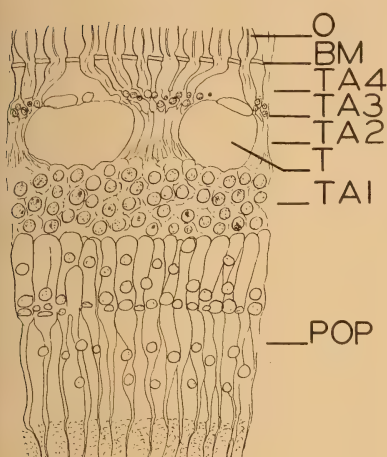


Fig. 6.

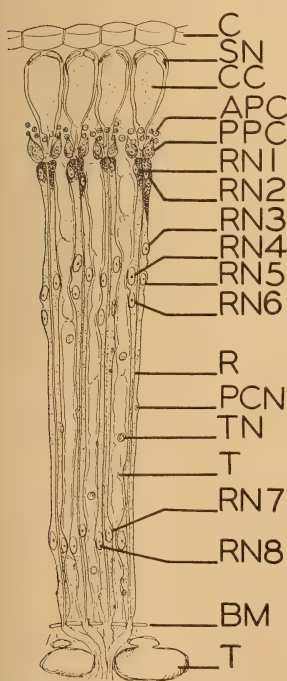


Fig. 5.

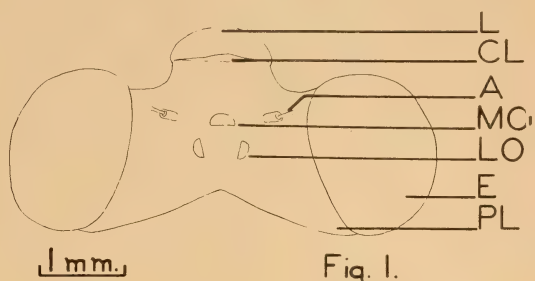


Fig. 1.



Fig. 2.

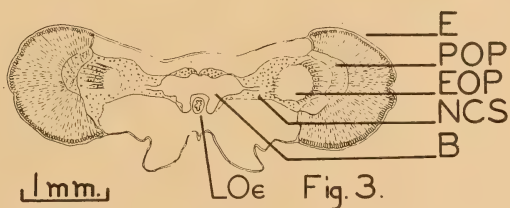


Fig. 3.

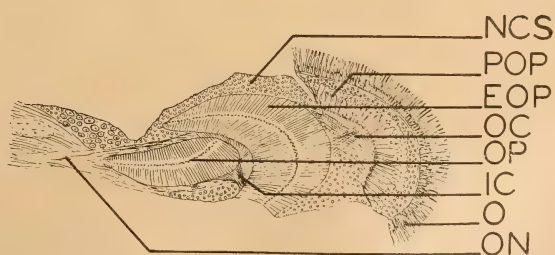


Fig. 4.

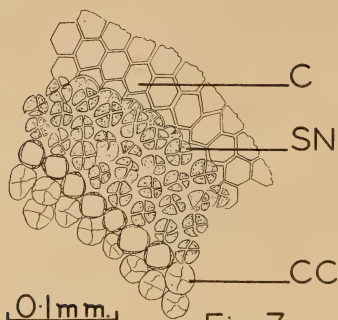


Fig. 7

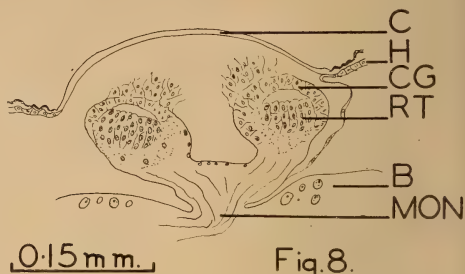


Fig. 8.

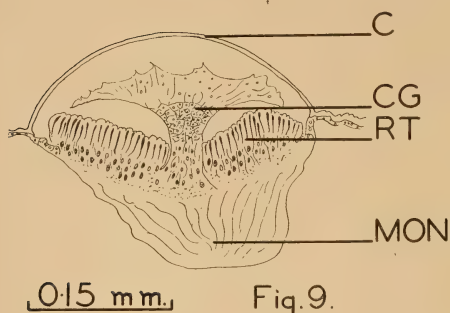


Fig. 9.

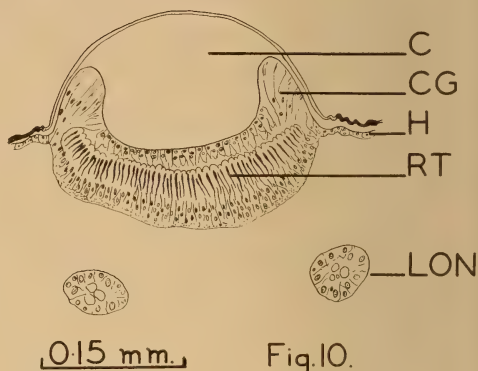


Fig. 10.

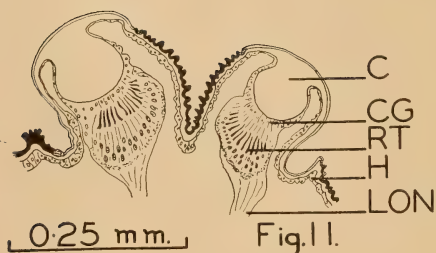


Fig. 11.

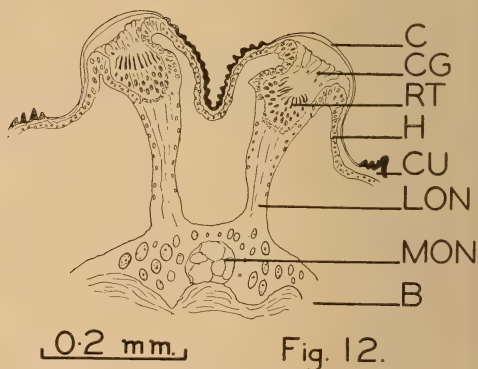


Fig. 12.

## LEGEND FOR FIGURES

- Fig. 1 — Dorsal view of head of *Lestes rectangularis*  
 Fig. 2 — Horizontal section of head and brain  
 Fig. 3 — Vertical section of head and brain  
 Fig. 4 — Vertical section of optic ganglia  
 Fig. 5 — Longitudinal sections of ommatidia  
 Fig. 6 — Longitudinal section of periophticon and terminal anastomosis  
 Fig. 7 — Tangential section of outer ends of ommatidia  
 Fig. 8 — Horizontal section of lower region of median ocellus  
 Fig. 9 — Horizontal section of middle region of median ocellus  
 Fig. 10 — Horizontal section of upper region of median ocellus  
 Fig. 11 — Vertical section through middle region of lateral ocelli  
 Fig. 12 — Vertical section through posterior region of lateral ocelli



A	— base of antenna	NCS	— nerve cell sheath
APC	— accessory pigment cells	O	— ommatidium
B	— brain	OC	— outer chiasma
C	— cornea	Oe	— oesophagus
CC	— crystalline cone	ON	— optic nerve
CG	— corneagenous cells	OP	— opticon
CL	— clypeus	PCN	— nucleus of retinal pigment cell
CU	— cuticle	PL	— postocular lobe
E	— compound eye	POP	— periopticon
EOP	— epipticon	PPC	— principal pigment cell
H	— hypodermis	R	— rhabdom
IC	— inner chiasma	RN 1-8	— nuclei of reticular cells
L	— labrum	RT	— retinula
LO	— lateral ocellus	SN	— Semper's nuclei
LON	— lateral ocellar nerve	T	— trachea
MO	— median ocellus	TA 1-4	— terminal anastomosis
MON	— median ocellar nerve	TN	— nucleus of tracheal cell



# SOME ASPECTS OF THE ECOLOGY OF THE CLOVER SEED WEEVIL *MICCOTROGUS PICIROSTRIS* (F.) (COLEOPTERA: CURCULIONIDAE)<sup>1,2</sup>

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The timing of insecticidal treatments is a most important factor in control. Although chemical control had been effective in reducing numbers of adults of the clover seed weevil, *Miccotrogus picirostris* (F.), in alsike fields (Heming, 1951), the proper time for application had not been determined since the spring movements of the weevils varied somewhat from year to year (Heming and Arnott, 1951). During an investigation to determine the factor or factors influencing the movement of the weevils, the effects of certain physical factors on the numbers coming into or in the crop were studied and are reported herein.

*M. picirostris* (F.), formerly known as *Tychius picirostris* Fab. and easily confused with *T. stephensi* Schönh., is a small grey weevil approximately 2.5 mm. in length. After the alsike has been harvested about mid-July, the "new" weevils<sup>3</sup> emerge from the soil and leave the field in search of nourishment and the protection of denser vegetation. Towards the end of August, these adults disappear completely, evidently moving into cover in fencerows, headlands and pastureland for the winter. The following spring, about May 1, weevils are found on the blossoming parts of such herbaceous plants as dandelion and wild strawberry, where they evidently feed on nectar. During the first week of June, as the alsike develops the first bloom, the weevils commence to move into the field. Here they feed, mate and oviposit.

To date the weevils have been reported from every Canadian province west of, but not including, Quebec and from Nova Scotia. In Ontario they have not been found east of Victoria and Durham counties. Reports indicate that this species is present in Oregon, Idaho, Washington, New York, Pennsylvania, Ohio, Utah, Indiana and Minnesota in the United States.

<sup>1</sup>Part of the programme of the Legume Research Committee in Ontario.

<sup>2</sup>Presented to the School of Graduate Studies of the University of Toronto, in partial fulfilment of requirements for the M.S.A.

<sup>3</sup>Adults of the new generation which emerge in July and August.



## METHODS AND MATERIALS

During the summer of 1951, daily sweeps were taken in a 4-acre stand of volunteer alsike at the W. F. Keith farm in eastern Norfolk County, from June 1 to July 14 inclusive. A sweep-net (12 inches in diameter, 3-foot handle) was used and each sweep covered approximately five square feet. One hundred single sweeps were taken at random every day at mid-morning. Similarly in 1953, sweeps were taken periodically in a 4-acre alsike stand at the Brampton Seed Farm in Peel County, to confirm population trends as noted during previous years.

In 1952, six large wooden wind-frames (Moreland, 1953) were placed at the margins of each of two fields, one on the L.B. Mehlenbacher farm at Kohler in Haldimand County, and the other at the Keith farm, as shown in Fig. 4. Each frame was provided with four vertical strips of kraft paper coated on the exposed side with Tanglefoot. These frames were examined daily from June 3 to June 23 inclusive.

## RESULTS AND DISCUSSION

Figure 1 shows the number of weevils collected daily by 100 sweeps at the Keith farm in 1951. Weevils appeared in the field on June 4 and their numbers rapidly increased to a maximum on June 16. It was reported by Arnott (1951) that the greatest number of weevils taken with 50 sweeps in alsike on this farm in 1950 was 400. This is only about one-quarter of the maximum of 2924 for 100 sweeps in 1951, and suggests that large weevil populations may build up if their principal host plant is grown year after year on the same farm or in the same immediate locality.

Although the peak population of June 16 was not reached again during the summer, numbers remained high until the end of June after which they slowly decreased, reaching a calculated 478<sup>4</sup> on July 14. By this time the alsike was ready for harvesting and the decrease in numbers may have occurred because the developing seeds were becoming too hard for successful penetration by larvae and adults or because of natural mortality.

On July 1, 1952, at the Mehlenbacher farm, 50 sweeps taken in an alsike field yielded 1196 adults. The stand was poor and sweeps were taken only in areas of pure or nearly pure alsike. Nevertheless, this is an extremely large population when one considers that alsike had not been grown on this farm or in the immediate area for several years. It is probable that when a population of these weevils builds up, only to have its main host crop discontinued, then it may survive on volunteer alsike, white Dutch, and Ladino clovers or in pasture mixtures.

Table I shows the number of weevils collected in 50 sweeps during the alsike blooming period at the Brampton Seed Farm in 1953.

TABLE I

ADULTS OF *M. PICIROSTRIS* COLLECTED IN 50 STANDARD NET SWEEPS AT THE BRAMPTON SEED FARM, 1953.

Date	No. of Weevils	Date	No. of Weevils
June 3	2	July 3	1091
8	3	7	1137
10	12	10	1030
15	298	14	1272
18	1383	16	898
19	513	20	589
22	1209	23	410
24	1359	27	293
27	1402	30	155
29	1617		

<sup>4</sup>Only 50 sweeps were taken instead of the usual 100.



The first weevils were seen on June 3, 1953, when a few white Dutch plants were in bloom in the alsike field. The alsike had not yet commenced to bloom. These data would indicate that the main movement of the adults, as affected by the alsike, began during the period June 8 to June 10, reaching a high point by June 18. The population of 1383 at this time was slightly exceeded toward the end of the month. The large decrease in numbers on June 19 may be

## KEITH FARM

1952

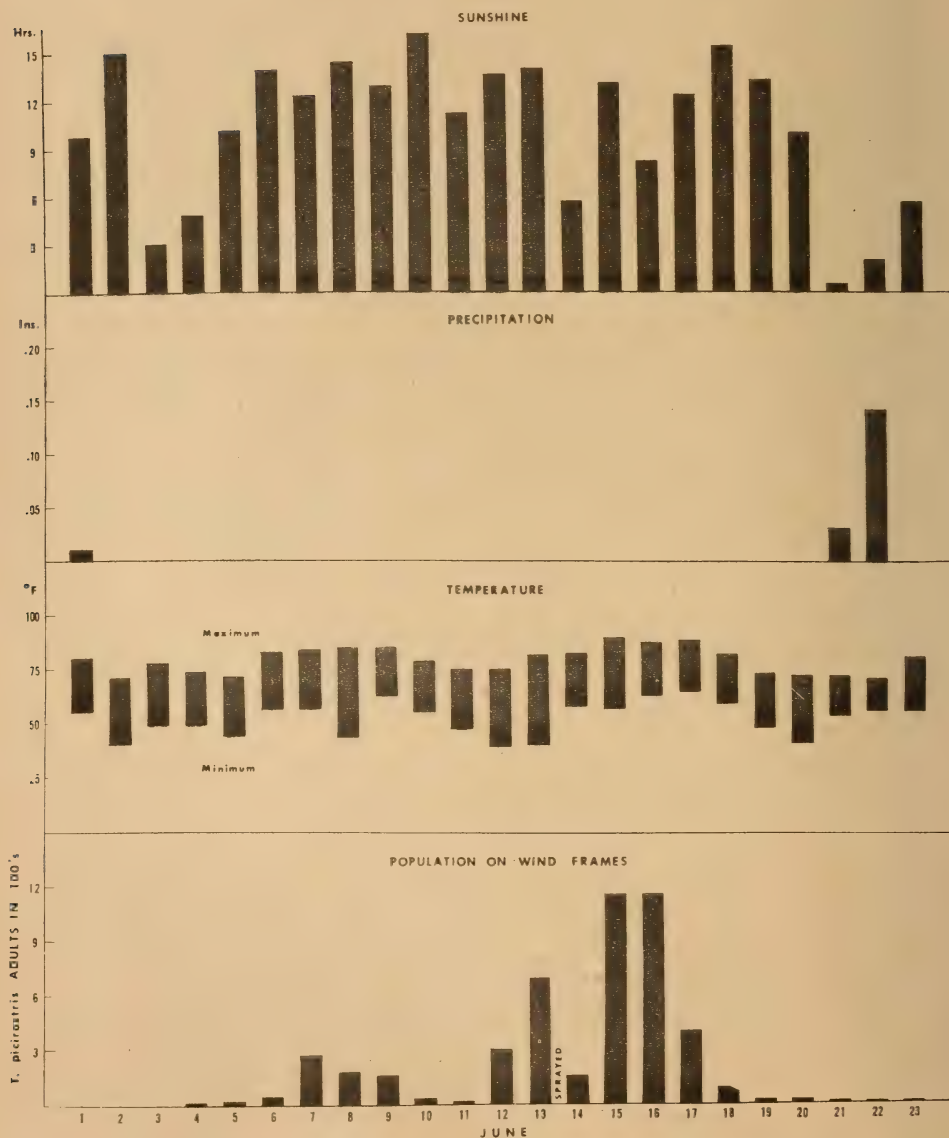


Fig. 2. Histograms of some weather factors and the aerial population of *M. picirostris* as recorded at the Keith farm in 1952.

attributed to spraying of the alsike surrounding the observation area on the evening of June 18. The population remained high until the middle of July after which the numbers decreased as the crop matured.

In Fig. 2, the total numbers of weevils found in 1952 on the six wind-frames at the Keith field are shown. Two population peaks are noted, a minor one on June 7 and another over the period June 15 and 16. The poor flight on June 14 can be attributed to the spraying of part of the field on the evening of June 13. After June 16, the amount of flight diminished as the weevils settled down to feed and oviposit after the main influx.

These data from the wind-frames confirmed the observation that the weevils move into the crop by flying. Large numbers of weevils were observed walking in and around the field, but the extent of movement by walking was not determined.

## II. THE EFFECT OF CERTAIN PHYSICAL FACTORS ON THE POPULATION

Recorded data on physical factors are frequently inadequate in that they often give only the extremes; whereas, the critical period might be somewhere between these points. Under field conditions, where only the macroclimate is being recorded, the effect of the factors on the population as a whole must be considered. It is then permissible to speculate that these effects are produced on the individual as well. Any conclusions reached must necessarily be general rather than specific.

The effect of such factors as hours of sunshine, precipitation, temperature, humidity, and wind on the population of *M. picirostris* adults, was studied at the Keith farm during the summers of 1951 and 1952.

The histograms in Fig. 1 give data on sunshine, precipitation, temperature and population counts by sweeping, as recorded in 1951. Humidity records for this period were found to be unreliable and are not reported. Figure 2, showing 1952 data, is similar to Fig. 1 for the same weather factors, but the weevil population figures were obtained from the wind-frames. Reliable humidity records were secured in 1952; these are discussed later.

TABLE II

POPULATION OF *M. PICIROSTRIS* IN 100 SWEEPS BEFORE AND AFTER RAINFALLS.  
KEITH FIELD, 1951

Date	Precipitation in inches	Population before rain	Population after rain
June 10	.07	385	317
13	.88	1571	1141
14	.01		
15	.04	1141	1895
20	.27	2480	1865
22	.49		
29	.09	2359	1947
30	.04		
July 1	.41	1947	1817
2	.44		
5	.78	1751	1173
10	1.35	1087	1025
11	.16		
12	.23	1025	975

A. *Light*. According to Arnott (1952), the weevils are positively phototropic. In his report, no mention was made of any crepuscular or nocturnal activity. Figures 1 and 2 indicate that the number of hours of sunshine each day had no apparent effect on the weevil population, either while on vegetation or in flight.

B. *Precipitation*. Chapman (1931) stated, "Heavy precipitation may act directly by mechanically removing certain insects from their host plants". *M. picrostris* adults, with the slightest disturbance of foliage or blossoms, tend to fall off the host plant. The summer of 1951 was wet while that of 1952 was dry. During the period in 1952 when the weevils were moving into the alsike in large numbers, no rain fell. Consequently, any effect that rainfall might have had on weevil activity could not be studied. In 1951, population figures were recorded before and after rainstorms. These are given in Table II. In each case, sweeping was done as soon after the rainfall as the foliage was reasonably dry, by the same person, and with the same insect net.

Populations, with one exception, were reduced after each rainfall. The exception occurred the day before the peak of population was reached. At this time, the weevils were moving continuously into the alsike field in such large numbers that any decrease that might have been caused by the slight rain could have been more than offset by the arrival of other weevils.

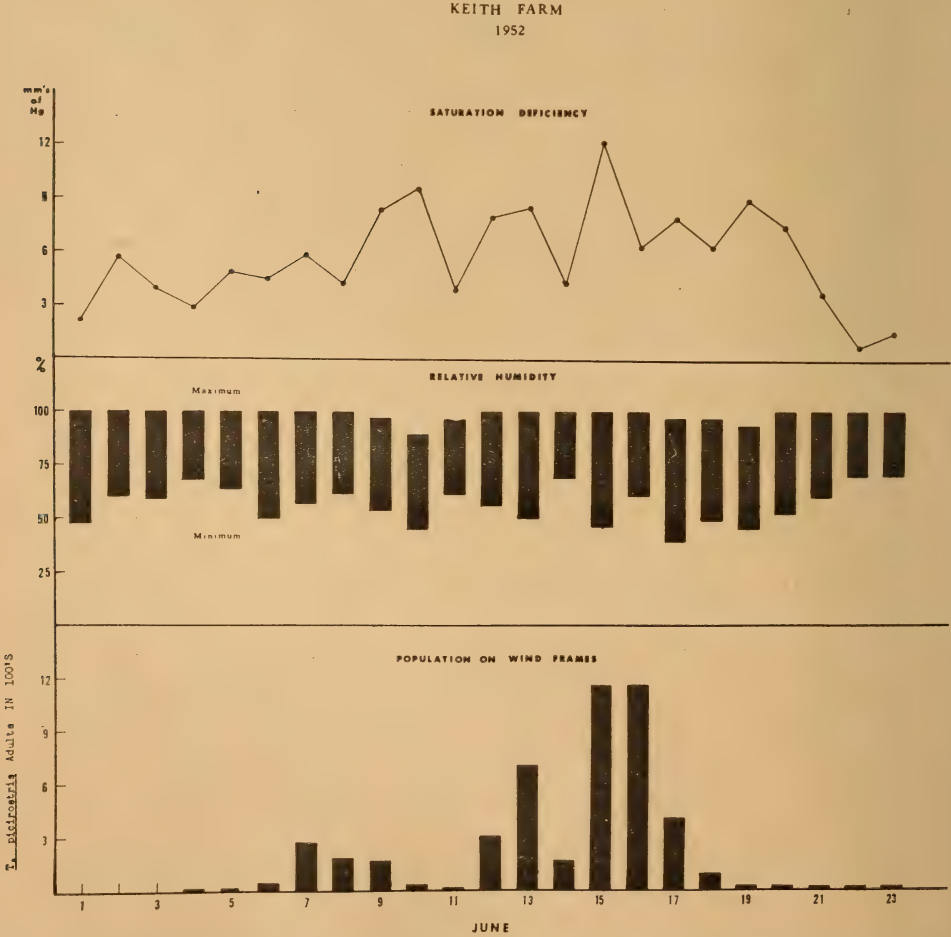


Fig. 3. The population on wind-frames and humidity records expressed in terms of relative humidity and saturation deficiency, Keith farm, 1952.





Fig. 4. Location of the wind-frame flight traps at the Keith and Mehlenbacher farms, 1952

Rainfall, unless quite light, has a disturbing effect on the weevils and some fall to the ground.

C. *Humidity*. In 1952, during the major flight period, daily wet- and dry-bulb temperatures were taken. From these records the daily maximum and minimum relative humidities were calculated. These data are included in Fig. 3. Saturation deficiencies, based on the mean of four, hourly, wet- and dry-bulb readings from 8:00 a.m. to 11:00 a.m. standard time, are also plotted in Fig. 3. These were determined from morning readings as the weevils have been shown not to move appreciably at night (Moreland, 1953). The weevils were collected from the wind-frames in the afternoon, a very time-consuming operation.

From an examination of these data, it would appear that humidity has no appreciable effect on the aerial population of *M. picrostris* adults.

D. *Temperature*. On the basis of the data in Figs. 1 and 2, it would seem that the normal daily variations in temperature in the fields are not factors of much importance in determining the population of adult weevils in a particular location.

E. *Wind*. In 1952, an extensive study on the effect of wind on the weevils was undertaken using wind-frames.

The frames were erected in the field margins of alsike stands at the Keith and Mehlenbacher farms and numbered as indicated in Fig. 4. Counts were made from June 3 to June 23 inclusive. In order to facilitate the taking of data on height of flight, each wind-frame was divided into 16 sections in the vertical direction, each section, except the lowest, being one foot in height. Each section had 4 Tanglefoot-treated surfaces totalling approximately 96 square inches. Section 1 was not used in taking counts (Moreland, 1953).

TABLE III  
AMOUNT AND DIRECTION OF WIND AND THE NUMBER OF WEEVILS  
COLLECTED ON THE WIND-FRAMES. KEITH FARM, 1952

Date	Amount of wind in miles from each direction <sup>1</sup>								No. of weevils per wind-frame					
									Wind-frame					
	N	NE	E	SE	S	SW	W	NW	7	8	9	10	11	12
June 4	14					5		41	2	1	1	1	1	3
5		8			6	29	2	15	3	1	2	4		3
6					33	93		9	15	2	9	5	5	5
7						44	24	39	26	11	14	88	70	62
8	4				42	28	5		13	46	96	10	8	7
9					62	65		26	28	62	52	14	2	6
10						139			10	8	12	1	2	1
11								217	2	3	3		1	1
12	7				19	17	13	38	6	44	75	129	33	12
13	9		5		7	4	8		72	91	120	106	173	141
14			29	12	63				30	23	39	31	24	11
15 <sup>2</sup>														
16	11	95	7		38		7	13	602	403	314	142	372	485
17		19		10		91			191	60	60	17	27	46
18						32	72	30	19	5	7	7	22	24
Totals	45	122	41	22	270	547	140	419	1019	760	804	555	740	807

<sup>1</sup>Calculated from 4 a.m. to 12 noon of the same day and from 6 p.m. to 9 p.m. of day before.

<sup>2</sup>Calculated from 4 a.m. to 9 p.m. inclusive.

Observations in the Keith field in 1952 showed that wind direction was identical with the continuous readings at the Long Point Meteorological Station, 35 miles away. Absolute velocities differed, but it was assumed that they would be relative. Consequently, the official records from the Station were used in this study.

The wind-frame population figures from the Keith field were used to determine the correlation between wind (direction and amount) and weevil numbers. Table III shows the number of weevils collected on each frame during the period June 4 to June 18 along with the wind direction and amount. Wind was calculated from 6 to 9:00 p.m. of the day before and from 4:00 a.m. until 12 noon of the same day. The afternoon period was omitted, because at this time the wind-frames were down for counting and removing captured weevils. Since the weevils do not move appreciably in the dark, records were not taken during the period from 9:00 p.m. to 4:00 a.m.

Reference to Fig. 4 will show that wind-frames 7, 8-9, 10 and 11-12, faced in the directions west, south, east and north respectively. In Table IV, the possible directions of wind to which each wind-frame was exposed and the number of miles of wind each frame experienced during the observation period, are given.

TABLE IV

THE DIRECTION OF WIND AND NUMBER OF WIND-MILES TO WHICH KEITH  
WIND-FRAMES WERE EXPOSED

<i>Wind-frame No.</i>	<i>Exposed to wind directions</i>	<i>Miles of wind by directions June 4 - June 18</i>
7	SW-W-NW	$547 + 140 + 419 = 1106$
8	SW-S-SE	$547 + 270 + 22 = 839$
9	SW-S-SE	$= 839$
10	NE-E-SE	$122 + 41 + 22 = 185$
11	NE-N-NW	$122 + 45 + 419 = 586$
12	NE-N-NW	$= 586$

The analysis of insect totals on wind-frames facing each direction and amount of wind to which each frame was exposed gave a correlation coefficient of +0.96. This led to the conclusion that the weevils in flight were carried or aided by wind. It was observed, however, that individuals could and did fly against winds of moderate velocity. This observation was supported by the counts of weevils trapped on wind-frames facing in the down-wind direction.

The wind-frame figures obtained at the Mehlenbacher farm were used to determine the preferred height of weevil flight. The field was flat and thus errors due to uneven topography were avoided. In Table V, the number of weevils found on each section of each frame during the observation period (June 3 to June 23) is given.

There was a high positive correlation of 0.94 between height of sections and number of weevils on each section. By the method of least squares the equation for the curve was determined to be:  $y = -1.4x + 38.2$  where  $y$  = the number of weevils. Substituting 0 for  $y$ , we find that  $x = 27.3$ , which indicates that the great majority of these weevils are likely to be found within 27 feet of ground level.

### III. INDICES FOR TIMING CHEMICAL APPLICATIONS FOR CONTROL OF *M. PICIROSTRIS* ADULTS

Of prime importance in the production of alsike seed is the possession of some index, usable by the farmer, to determine the proper time(s) for insecticide application. It was concluded by Arnott and Heming (1951), that a population assay by net sweeps would provide more accurate



TABLE V

THE NUMBER OF WEEVILS ON EACH SECTION OF THE WIND-FRAMES AT THE MEHLENBACHER FARM — JUNE 3 TO JUNE 23, 1952

Section	Wind-frame No.						Totals
	1	2	3	4	5	6	
2	36	40	19	19	35	51	200
3	37	43	23	27	47	47	224
4	37	31	24	21	43	51	207
5	29	34	23	28	44	32	190
6	33	15	20	28	33	36	165
7	37	25	35	21	34	27	179
8	22	21	16	25	36	26	146
9	20	25	17	19	26	18	125
10	36	23	21	26	30	28	164
11	15	20	19	17	24	31	126
12	31	17	14	34	33	28	157
13	26	16	15	14	25	17	113
14	17	10	13	23	33	22	118
15	24	13	12	16	23	24	112
16	8	4	6	17	27	19	81
Totals	408	337	277	335	493	475	2307
General Mean							25.6

Table VI shows a trend for the weevils to decrease in numbers as height was increased.

TABLE VI

THE MEAN NUMBER OF *M. PICIROSTRIS* ADULTS PER WIND-FRAME SECTION AT THE MEHLENBACHER FARM

Section	Mean	Section	Mean
2	33.3	9	20.8
3	37.3	10	27.3
4	34.5	11	21.0
5	31.7	12	26.2
6	27.5	13	18.8
7	29.8	14	19.7
8	24.3	15	18.7
		16	13.5
Necessary Mean Difference for Sections			
			(5%) 7.5
			(1%) 9.9

timing data than the degree of bud and blossom development, although they felt that the amount and stage of bloom throughout the crop season had a greater influence on the development and progress of weevil infestation than meteorological factors such as mean daily temperature or rainfall. To make population assays by insect net sweeps would be difficult for an Ontario grower, moreover, he would require some previous knowledge as to fluctuations in, and manner of, population increase in the alsike. Western growers who specialize in legume seed production, however, have insect nets as part of their usual equipment. Heming (1952) stated that the first insecticide application should be administered "when from 10 to 15 alsike heads in every square yard show some brown, basal florets". This, too, might be difficult for the

average grower to determine. The stage in development of numerous herbaceous and woody plants was observed in the hope of detecting some correlation with weevil movement, but without success. It was realized, too, that these plants would not necessarily be present on all southwestern Ontario farms.

In 1951, the honeybee, *Apis mellifera* L., was observed at the Keith farm to be working the alsike the day after weevil movement began. In 1953, bees began to work the alsike two days after the weevils began to increase in the field. On the basis of these observations, and since honeybees are recognized by most farmers, the presence of foraging honeybees in alsike could be used as an index to determine accurately the proper time for an application of an insecticide.

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## ALFALFA POLLINATION IN SOUTHERN ONTARIO<sup>1</sup>

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In the older established alfalfa seed-growing areas of North America, seed production has declined over the past three or four decades. In Haldimand, Peel and Halton counties — once the high seed-producing areas of Ontario — present seed yields are only a fraction of those

<sup>1</sup>Part of the programme of the Legume Research Committee in Ontario.

obtained during the period 1900 to 1930. At one time, alfalfa was believed to be self-fertile but later it was recognized that tripping and cross-pollination were essential for seed production. Various agencies are known to be capable of tripping the alfalfa blossoms but of these the most important are the insects that visit the flowers for pollen.

A substantial part of the decline in seed-yields may have resulted from a reduction in the number of pollinating insects. The species of insects responsible for pollinating seed-crops have been determined in many of the alfalfa seed-producing areas of the world. In southern Ontario however, they have received little attention. Sladen (1918) discussed the importance of the bumblebees, leaf-cutting bees and honeybees in the Ottawa area. Englebert (1932) recorded two species of halictids and two species of andrenids from alfalfa at Guelph. This investigation was undertaken to provide information on the species and abundance of the insect pollinators of alfalfa, their ecology and relation to seed production in southern Ontario.

### HISTORICAL

The importance of insects in the pollination of flowers was first recognized by the German biologist Kölreuter in 1761 (Plath, 1925). Since that time much has been written on the relationship of flowers and insects. The interesting and complex flowers of the leguminous plants have held the interest of many workers since the beginning. DeCandolle (1832) believed that the exploding or tripping of alfalfa occurred of its own accord when a certain stage of maturity was reached. Henslow (1867) observed the honeybee to visit the alfalfa for nectar only. Muller (1873) however, was the first to produce an extensive work on alfalfa; in it the tripping mechanism was described.

Research on seed-setting in alfalfa was started in the early 1900's on a small scale and in the 1940's investigations were at an all time high. In Australia, Scandinavia, Russia, and North America workers searched for the causes of the seed production problem in their own areas.

In 1903, Roberts and Freeman of Kansas showed that there was great variation within the plants themselves in their ability to set seed. In the same year Westgate concluded that alfalfa set seed in paying quantities only when there was a low moisture supply. The importance of the weather and climate has been discussed also by Willis and Bopp (1910), Aicher (1917), Alter (1920), and Englebert (1932) and others.

Carlson and Stewart (1921) showed that heavy applications of manure were detrimental to seed production and Whornham (1936) was unable to obtain any increase in seed yields by means of fertilizers.

The importance of injurious insects as a factor in seed-setting has been investigated by Seamans (1926), Carlson (1940), and others. Damage produced by insecticides and farm practices have been discussed by Tysdal (1940), Hambleton (1944), Peck and Bolton (1946) and Linsley and MacSwain (1947a).

A few workers contended that tripping, or at least insect visitation, was not essential for seed setting in alfalfa. Such were the findings of Willis and Bopp (1910), Piper *et al* (1914), Blinn (1920), Coffman (1922), and Hay (1925).

The use of honeybees in alfalfa seed production was recommended by Hambleton (1944) and his claims were supported by Carlson, Sorenson, and Bohart (1950) as well as by workers in other parts of the world. The value of the honeybee in this respect was criticized by Sladen (1918), Harrison *et al* (1945), Peck and Bolton (1946), and Harrison (1948).

Brand and Westgate (1908), and Westgate (1912) concluded that insect visitation and tripping were essential in seed-setting. The value of native wild bee populations was recognized by many workers, among whom were Sladen (1918), Waldron (1919), Gray (1925), Southworth (1928), Lejune and Olson (1940), Tysdal (1940 and 1946), Linsley (1946), Peck and Bolton (1946), Vansell and Todd (1946 and 1947), Bohart (1947 and 1951), Linsley and MacSwain (1947), Akerberg and Lesins (1949), and Harrison (1951).



While the importance of insect visitation and tripping of alfalfa flowers was being studied, it was natural that artificial tripping should be attempted with the hope of producing profitable seed yields. Carlson and Stewart (1921), Clark and Fryer (1930), and Carlson (1930), as a result of small scale tests, concluded that yields were increased by this means. On the other hand Silver-sides and Olson (1941), and Pederson and Todd (1948), using large scale tests, reported that the results were not beneficial.

### TECHNIQUES

Alfalfa fields in Halton, Haldimand, Wellington, Norfolk, Simcoe and Bruce counties were studied in 1951. In 1952 fields in these counties and also in Kent, Lambton, Middlesex, Brant, Waterloo, Dufferin, Peel, Perth and Wentworth were visited during the peak of the bloom period. Fields that showed little or no tendency to set seed and that were decidedly lacking in wild pollinators did not receive further attention. Early in this investigation it was realized that bees were the only insects that visited, tripped and pollinated the alfalfa flowers. Leaf-cutting bees, bumblebees, some andrenids and halictids were the most consistent pollinators, while honeybees were inefficient and unreliable.

With the first appearance of wild bees in the spring, flowering plants were checked for pollinating insects. Extensive collections were made on first and second stands of red clover and alfalfa, on alsike, sweet clover and on the wild flowering plants, whose bloom period coincided with that of the alfalfa. The genus and species of all the wild bees that visited and pollinated alfalfa were determined and records made of their flower-visiting habits in the field. Plants that competed with alfalfa for bee visitation were studied to determine their influence on the pollinating insects. Nesting-sites and nesting-habits of the wild bees were studied wherever possible. The upper Bruce peninsula was found to have largest concentration of wild bees on alfalfa and it was this area that received most of the attention in 1952.

The bee populations in some alfalfa fields were calculated on the basis of 100 net-sweeps with a standard 12 inch net provided with a 3-foot handle. One full net-sweep (through 180 degrees) was taken every second or third step as one progressed, depending upon the size of the field. This method gave a more accurate picture as the bees were not disturbed before each sweep and a greater proportion of the field was covered in obtaining the 100 net-sweep sample.

Square yard counts were taken in some fields by means of a mechanical measuring device which had been developed by the Department of Apiculture (Smith and Townsend, 1952). In others, where the wild bee population was low, counts were based on 10 square-yard samples. These measurements were made by taking 10 long steps and counting the number of bees that passed under the 3-foot handle of the net held out horizontally and waist high. The counts from the latter method multiplied by 484 gave an approximate population per acre. In fields where there were several species of bees visiting the alfalfa, counts were taken of 100 to 200 bees and the number of each species recorded. Data obtained in this way were used to calculate the number of each species per acre from the figures of acre-counts based on other sampling methods.

Carlson *et al* (1950) estimated that 1 pollen collecting bee per 10 square yards, in a period of three weeks, was sufficient to produce 400 pounds of alfalfa seed per acre, under Utah conditions. During the present study these data were used to estimate the seed-producing capacity of the alfalfa fields in southern Ontario.

### WILD BEES AND THEIR FOOD SUPPLY

Under natural conditions, in the less extensively farmed areas of Ontario there are, at times, fairly large acreages of wild flowering plants. The gradual build-up of blossoming reaches its peak during the last two weeks of June and then declines until fall when goldenrod is practically all that remains. Extensive cultivation has reduced the amount of native bloom so that roadsides and pastures are the principal areas where large communities of the early bloom may be found. The most important of the early blooming plants is the dandelion (*Taraxacum* spp.). Since the flowering trees are in bloom for such a short time and most legumes and flowering

weeds, — e.g. blueweed (*Echium vulgare* L.), thistle (*Cirsium* spp.), chicory (*Cichorium intybus* L.), cinquefoil (*Potentilla recta* (L.)), St. John's-wort (*Hypericum perforatum* L.) and others are not in bloom until the middle of June or later, most bees are dependent upon dandelion for early forage. The destruction of this vital food supply by weed-killing chemicals and the severe competition from large numbers of honeybees may have serious effects upon the wild bee populations in some areas.

In Ontario since 1888, the acreage of red clover and alfalfa has increased from  $2\frac{1}{4}$  to almost 4 million acres. Most of the first-cut alfalfa and red clover is used for hay, the second-cut in some cases being left for seed. The effects of cutting most of Ontario's 4 million acres of leguminous crops at the time when bumblebee colonies are beginning their rapid build-up and many of the solitary bees are starting to build their nests, must be considered. Colony development and nest-building would be retarded and the bees that were dependent upon the legumes for pollen and nectar must turn to wild flowering plants. Since few areas of the Province are without a high honeybee population, the cutting of large tracts of legumes will result in an overcrowding of the wild flowers to a point where the wild bees will be seriously affected. The position of the honeybee was well stated by Pearson (1933) ... "so efficient is it as a collector of pollen and honey and so ubiquitous has it become that there can be no question but what its inroads cause a serious diminution of the food supply of native bees, particularly in bad seasons".

Salt (1940) recommended that alfalfa, white Dutch and sweet clover hay crops, be cut early if their bloom-period is coincident with that of the alfalfa seed crop. Such a procedure would limit the acreage in bloom at any one time and tend to keep the available population from spreading too thinly over the crop to be pollinated.

#### BEEES OF THE GENUS BOMBUS

Bumblebees are among the largest and most conspicuous of all bees. In Ontario, 19 species and varieties have been recorded and 15 of these were taken by the writer during 1951-52.

The time of emergence in the spring varies somewhat with the species as well as with the individual. Some time after emerging the queens begin the task of finding suitable nesting sites which, according to Plath (1934), may take as long as six weeks. Queens have been observed nest-hunting during the first week of August in Ontario. The nest of one species was taken on October 9, at which time there was still considerable brood present.

According to Sladen (1912) and Plath (1934) the first workers appear about 22 days after the nest is established. The early supply of pollen and nectar required by the queen herself and by the developing larvae, is generally provided by dandelion, fruit trees, hawthorn (*Crataegus* spp.) and other early flowering plants. Usually the clovers and alfalfa are in bloom by the time the first workers appear. With their appearance the queen normally does not leave the nest again and when the second brood appears, food requirements increase rapidly.

A food-chain may be a vital factor in the establishment of bumblebee colonies in any one area. During the week of June 3-9, 1951, large numbers of queen bumblebees (*Bombus vagans*), were seen on the hawthorn shrubs bordering an alfalfa field at Arkell. No workers of this species were observed on alfalfa or the other flowering plants in the immediate area during the remainder of the summer. The food supply evidently diminished before nests could be established and the queens were forced to move to other areas.

#### Foraging Habits

During the blooming periods of both first and second alfalfa stands, bumblebees showed a preference for other wild and cultivated plants. Where alfalfa and red clover were mixed or where the fields were side by side, the alfalfa received little or no attention. Under normal conditions each individual bumblebee can spend the entire day gathering pollen and nectar whereas each solitary bee spends considerable time locating and preparing the nest for provisions. The population of bumblebees builds up gradually to a peak that may coincide with the bloom-

period of some leguminous crops. The number of solitary bees present during the year, in most cases, is entirely dependent upon the number that over-wintered successfully in the cells provisioned the previous season.

Bumblebees are active for longer periods each day and are less affected by temperature changes than are other bees. They were observed to be active on red clover when the temperature was 50 degrees F. at 8:30 a.m. Various species of *Bombus* have been observed to visit flowers after the sun had set. It is known that workers frequently remain in the field overnight (Rau, 1924) and in the Guelph area individuals of *B. fervidus* and *B. americanorum* were observed in an inactive state on blueweed and thistle plants after sunset.

Bumblebees are known to visit and pollinate the alfalfa flowers. The numbers of species and individuals found on the crop in the more extensively farmed areas of Ontario, however, were extremely variable and in most cases too low to produce profitable seed yields.

Alfalfa fields on the Bruce peninsula were investigated first on September 4, 1951. At this time the bumblebee population was as high as 1200 per acre. The same fields in 1952 had a population of about 1600 per acre.

### Biological Observations

The habits of one species of bumblebee may vary considerably from those of another. The time of emergence in the spring, preferred nesting-sites, size of colony, foraging habits and enemies are factors to be considered in estimating the value of each species in alfalfa pollination. The flower-visiting rate and tripping efficiency of each species are given in Table I.

*B. americanorum* Fab. appears about the middle of May in southern Ontario. Plath (1927) stated that this species was most common in the Middle West but rare in New England. In southern Ontario it was among the more common bumblebees in 1951-52. Four nests were found: two at ground level, one in a hollow root of a stump fence and the other in the second story of a farm building. All colonies were vigorous but they did not appear to be particularly large. Graenicher (1935) reported the males of this species to be among the earliest to appear, commonly in the first week of August. In the nests under observation at Guelph, males appeared during the first week of September and near Jarvis, they were seen flying around a nest on September 24.

This species was observed in small numbers in alfalfa fields at Guelph and further south. Red clover was a preferred plant but blueweed, sweet clover, sow thistle (*Sonchus arvensis* L.) and bull thistle were also attractive.

The bee, *Psithyrus variabilis*, reported to be a parasite of *B. americanorum*, is not known to occur in Ontario.

*B. affinis* Cress. according to Plath (1922), nests only below the ground and in 1934 he reported that they preferred the nests of chipmunks. Queens of this species appeared early in May in the Guelph area. *B. affinis* is considered to be short-tongued when compared with other species and is reported to have the habit of biting holes at the base of the larger, deeper flowers in order to obtain nectar. This habit was not observed during the present study.

In most fields *B. affinis* was not very abundant. On the Bruce peninsula they numbered 38-40 per acre in 1951 but in 1952 they were rarely found. They were most abundant on red clover but were also found on thistles, blueweed and sweet clover.

Plath (1934) reported that *Psithyrus ashtoni* was a serious pest of this species.

*B. auricomis* Robt. nests both above and below ground, according to Plath (1934). In Ontario this species is rare and only one specimen was observed on alfalfa. Flower-visiting and tripping rates were not recorded.



*B. bimaculatus* Cress. was reported by Franklin (1912) and Plath (1934) to nest at and below ground level. According to the latter investigator, queens appear very early and colonies "break up" in August. A few specimens were observed on spreading dogbane (*Apocynum androsaemifolium* L.), common comfrey (*Symphytum officinale* L.) and wild bergamot (*Monarda fistulosa* L.) but not on leguminous crops.

*B. borealis* Kby. is thought to nest below the ground. One nest of this species was found under a small pile of rocks at ground level. On the Bruce peninsula, the number of workers in alfalfa varied from 125 to 250 per acre. Some workers visited as many as 39 florets per minute but tripped only a few of these, thus accounting for the lower tripping efficiency of this species (Table I).

Red clover is preferred by this bumblebee and in the Guelph area the males were as numerous as the females in some of the red clover fields observed.

*B. fervidus* Fab. is by far the most common bumblebee in the more southerly areas of the Province. Many nests of this species were found by Putnam (1865), Franklin (1912), and Plath (1922). The numbers of individuals in alfalfa fields in southern Ontario were rather low. On the Bruce peninsula their numbers reached 600 per acre in 1952. Near Cayuga, a nest of this species was located within an alfalfa field but workers were not observed to visit the flowers. The nest was visited several times during the bloom-period and most of the workers returned to it from the direction of a red clover field about a mile to the north.

No species of *Psithyrus* has ever been found established in a nest of *B. fervidus*. This is attributed to the "daubing" habit described by Plath (1922).

TABLE I.—Flower-visiting rate and tripping efficiency of bumblebees on alfalfa in southern Ontario.

Species	Flower-visits per minute	Tripping efficiency in per cent
<i>B. americanorum</i>	16—20	80
<i>B. affinis</i>	16—21	55
<i>B. auricomis</i>	—	—
<i>B. bimaculatus</i>	—	—
<i>B. borealis</i>	19—39	35
<i>B. fervidus</i>	14—28	73
<i>B. fervidus</i> var. <i>dorsalis</i>	—	—
<i>B. griseocollis</i>	19—32	50
<i>B. impatiens</i>	16—22	70
<i>B. perplexus</i>	—	—
<i>B. rufocinctus</i>	—	—
<i>B. ternarius</i>	20—24	56
<i>B. terricola</i>	18—21	60
<i>B. vagans vagans</i>	14—16	49

*B. fervidus* var. *dorsalis* Cress. is similar in its field habits to *B. fervidus*. A few workers and one queen were taken on red clover in the Guelph area. One nest of *B. fervidus* taken in 1951 contained four workers which lacked the black interalar band that distinguishes *B. fervidus* from this varietal form. In the western United States this variety has been reported by Vansell and Todd (1946) to be an efficient pollinator of alfalfa.

*B. griseocollis* DeGeer is a surface nesting species, according to Plath (1927 and 1934). This species was uncommon in most parts of the Province. Alfalfa fields on the Bruce peninsula had

25–40 per acre in 1951 and 1952. Males and nectar-gathering workers visited as many as 32 blossoms per minute but without tripping. Males and workers were most commonly found on red clover and many of the wild flowers were attractive food sources.

*B. impatiens* Cress. is reported by Plath (1922 and 1934) to build its nest below the surface of the ground. He described one very large colony in which there were about 1000 individuals. Workers of this species were found in nearly all of the alfalfa fields visited but always in small numbers.

*B. perplexus* Cress. was reported nesting between the walls of a building by Franklin (1912) and below the surface of the ground by Plath (1922). The latter worker in 1934 reported that the colonies broke up early in the year and that individuals were rarely found after August 19. In Ontario, males have been taken on August 14 and queens as late as September 5. Only two specimens were taken from alfalfa but the species may be more abundant than it appeared because of the difficulty in the field of distinguishing the workers from those of *B. vagans*.

*B. rufocinctus* Cress. was reported nesting between the walls of a house by Plath (1934). Two nests of this species were taken during the present study. One, in the ceiling of an old building, the other in an old mouse's nest under a flat rock. The species was not commonly in southern Ontario and workers were never observed to visit alfalfa flowers.

Peck and Bolton (1946) reported this species to be a pollinator of alfalfa in northern Saskatchewan. In Utah, it has been reported from alfalfa by Vansell and Todd (1946).

*B. ternarius* Say was taken by Putnam (1865), and Plath (1922) located a nest in the ground among some trees near a red clover field. The two nests of this species found by the writer were in the soil. One had its tunnel entrance in a patch of bare ground near a small maple grove. The other was in a grass-covered, rocky slope at the edge of a large grove of trees. On the Bruce peninsula, workers were active pollinators of alfalfa. Field samples in the area indicated a population of 56–127 per acre. At the edge of one field a worker visited flowers of alfalfa, red clover, alsike, wild carrot (*Daucus carota* L.), goldenrod (*Solidago* spp.), and one other plant, all in a period of 10 minutes.

*B. terricola* Kby. nests below the ground with a long tunnel extending to the surface (Plath, 1922). In 1927, he reported that colonies contained less than 50 individuals. One nest located by M. V. Smith, Department of Apiculture, Guelph, in the sawdust of an ice house had a tunnel about six feet long and contained 74 bees and considerable brood. The total strength of the colony was estimated to be at least 120 individuals. Another nest was located, by the writer, in a dense grove of trees. The tunnel entrance was among the dry leaves and continued down among the rocks in an area where the soil was rather shallow.

This species, one of the short-tongued bumblebees, obtains nectar from long flowers by biting a hole in the base of the corolla tube. Queens were observed to mutilate the flowers of common comfrey and workers were seen to bite holes at the base of red clover florets. In general this species was not abundant and was rarely seen on alfalfa. On the Bruce peninsula, workers numbered from 380–720 per acre in alfalfa fields but were never observed to mutilate the flowers.

Plath (1922) stated that he had never observed workers of this species after September 1. On the Bruce peninsula workers were actively visiting alfalfa during the first two weeks of September and males were taken at Guelph on September 17.

*B. vagans vagans* Sm. nests both above and below the ground (Plath, 1934). The two nests located by the writer in 1951–52, were above ground. Workers were common in most parts of the Province but were not taken on alfalfa except on the Bruce peninsula where in 1952 their numbers varied from 50–150 per acre. Most of the flowering plants were attractive pollen and nectar source for this species but red clover and thistle were the most common source of food.

## BEES OF THE GENUS MEGACHILE

The cells of the nests of this group of solitary bees are constructed of bits of leaves in tunnels in soil, wood or pithy stems. Each cell is partially filled with pollen and nectar before an egg is laid and the cell closed. The larvae spin their cocoons in the autumn and adults emerge the following spring. Fabre (1915) stated that each cell consisted of about 45 leaf-pieces. A cell of *M. latimanus* examined by Mitchell (1936) consisted of 34 pieces.

A variety of plants have been reported as sources for nest-building material. Some of those mentioned in the literature are: peas and ash-leaved maple (Guignard, 1887); lilac (Friese, 1923); rose leaves and petals, and seedling oak (Mitchell, 1936); and strawberry leaves (Stevens, 1949). The sources of nest-building material received some attention during the present study. These are listed as a group below and the host plant preferences of the several *Megachile* species are discussed elsewhere:

- Corylus cornuta* Marsh. (Beaked hazel).
- Polygonium scandens* L. (Climbing false-buckwheat)
- Chenopodium album* L. (Lamb's-quarters)
- Prunus americana* Marsh. (Wild plum)
- Prunus* sp. (Wild cherry)
- Acer nigrum* Michx. (Sugar maple)
- Tilia americana* L. (Basswood)
- Viola tricolor* L. (Pansy)
- Epilobium angustifolium* L. (Fireweed)
- Apocynum androsaemifolium* L. (Spreading dogbane)
- Gaillardia* sp. (Blanket-flower)
- Rosa* sp. (Wild. rose).

In the woods surrounding alfalfa fields on the Bruce peninsula the sugar maple was the most common source of leaf-pieces. It was difficult to find a maple tree that did not show evidence of leaf-cutting bee activity. Two young trees, about 15 feet high, were examined near one field and some leaves had as many as 18 separate notches cut out by the bees. Leaves on all parts of the tree were used and a count of 25 leaves chosen at random showed an average of 2 cuts per leaf. The leaves of older trees were used but seedling and suckers at the base of the trees were used to the greatest extent.

It has been suggested by Peck and Bolton (1946) and others, that the population of leaf-cutting bees might be increased by growing suitable plants near the fields as leaf sources. In some cases this might serve to reduce the time spent in locating and carrying leaves to nesting-sites. A shortage of nest-building material does not appear to be a factor governing the abundance of leaf-cutting bees in southern Ontario.

Suitable nesting-sites appear to be of more importance than nest-building material. The four most important *Megachile* in alfalfa pollination on the Bruce peninsula, nest in the soil, for the most part. Areas where large numbers of bees were nesting had never been cultivated. There was little grass and few other plants. The soil was stoney and small flat rocks, from 5 to 12 inches in diameter were abundant on the top of the ground.

Several species of *Megachile* are known to nest in galleries in wood, hollow stems and other sites above the ground. The gradual replacement of stump and rail fences may have accounted for some reduction in the numbers of these species. In some parts of the province demonstration and farm wood-lots are almost the only "wild" land available for species that nest in wood. Dead and dying trees in these lots are usually systematically removed and thus the nests and nesting-sites have been destroyed.

When alfalfa was first grown on a small scale in northern Saskatchewan, the seed yields were heavy. The eagerness of the farmers to grow seed on a large scale had drastic results. Land was cleared and alfalfa sown on large acreages and much to the surprise of the growers,



yields dropped to a point where they were no longer profitable. Recommendations have been made by the Canada Department of Agriculture in an effort to stabilize seed-growing in these areas. Long, narrow fields of a limited size (5-10 acres) with wild, undisturbed land on both sides now are producing seed consistently.

#### *Foraging Habits*

The leaf-cutting bees are solitary in habit. Each cell is individually constructed and provisioned with all the pollen and nectar required by the developing larva. Nectar and pollen are seldom gathered separately by the *Megachile* as they are by honeybees and some bumblebees.

In general, the population of leaf-cutting bees in southern Ontario is very low. A 30-acre field of second-cut alfalfa near Georgetown was visited on five occasions in 1951 and twice during the first bloom-period in 1952. *Megachile* were not found in this field. Four fields in Haldimand county were visited in 1951, once during the first bloom-period and twice during the second bloom-period. The only *Megachile* observed were on sow thistle, burdock and elecampane in nearby fields. The alfalfa fields in Halton county were much the same. Wellington country fields had a low population in some areas but this was insufficient for profitable seed yields.

On the Bruce peninsula two fields of alfalfa in late bloom were sampled for bee populations during the first week of September, 1951. Thirteen bumblebees and 5 leaf-cutting bees were recorded from 50 square yards in one field and 25 bumblebees and 2 leaf-cutting bees from 90 square yards in another. Calculations indicated the leaf-cutting bee populations to be 485 and 108 bees per acre, respectively. The latter field was studied again in 1952. Square yard samples taken on August 3 indicated about 2000 bees per acre, of which 17 per cent or 340 were *Megachile*.

In Simcoe county two fields of first-cut alfalfa were visited in 1952. A small field near Creemore had an excellent leaf-cutting bee population. Nine *Megachile* and six honeybees were recorded from fifty square-yard samples. This represented a population of about 870 *Megachile* and 580 honeybees per acre. Bumblebees and leaf-cutting bees were abundant in an alfalfa field at Camp Borden but square yard samples were not taken.

*Megachile* are most active on sunny days during a relatively short period of time. This period is normally from about the middle of June until the end of August. Most of the species have been reported from a wide variety of flowering plants (Mitchell, 1936). On the Bruce peninsula in 1952, most dandelions had disappeared before the time of *Megachile* emergence. Volunteer white Dutch clover, alsike, St. John's-wort and cinquefoil were the principal plants visited by this genus before alfalfa came into bloom. Mitchell (1936) reported that *M. latimanus* and *M. inermis* had been observed on dandelion. Under some conditions this plant may play an important role in providing food during early critical feeding periods.

During the peak of alfalfa bloom on the Bruce peninsula, the *Megachile* were rarely observed on the relatively few wild flowering plants present. In 1951, late-cut alfalfa was in bloom until after September 5. Under such conditions the bees were assured of continuous bloom and a food source until both the plants and the bees were destroyed by early frosts.

#### *Biological Observations*

The species of *Megachile* vary considerably in the time of emergence, nesting-sites, nest-building materials, and pollen and nectar sources. These factors must be considered in evaluating them as pollinators of alfalfa. The flower-visiting rates and the tripping efficiency of each species are given in Table II.

*Megachile* (*Litomegachile*) *brevis* Say is one of the smallest and one of the most widely distributed of the leaf-cutting bees, occurring throughout the United States and the more southerly parts of Canada. It appears about the middle of June in southern Ontario and persists until autumn frosts. The flower-visiting records of this bee are numerous and there are apparently few flowers which are unattractive to it.

Observation of the various authors on the nests of *M. brevis* are given by Mitchell (1934). Nests have been reported in rolled-up leaves of a plum tree, in the stem of sumac, in a railroad tie, and in the soil. The only nests found in 1951-52 were in the soil under flat stones or under the basal leaves of small plants. Most of the nests consisted of a single cell and those under leaves of small plants had the anterior end exposed at the surface of the soil. This species utilizes a wide range of plants as sources of nest-building material. Among those observed were wild plum, beaked hazel, sugar maple, spreading dogbane, pansy and blanket-flower.

On the Bruce peninsula in the area under observation, alfalfa was the major source of pollen and nectar for this species. A few females were taken on musk-mallow (*Malva moschata* L.), sweet clover, cinquefoil and St. John's-wort before alfalfa reached full bloom. Their numbers ranged from 48-80 per acre on the peninsula to zero or only the occasional specimen in other parts of the Province visited.

"Parasitic" bees of the genus *Coelioxys* are closely related to the *Megachile* and *C. 8-dentata* Say has been recorded from the nests of *M. brevis*.

*Megachile* (*Litomegachile*) *texana* Cress. has a distribution pattern similar to that of *M. brevis*. Flight periods, flower-visiting habits and local distribution were also similar to the forementioned species.

Nests taken in 1951-52 were in the soil in the same area where *M. brevis* was found. Females of *M. texana* were observed cutting leaves from beaked hazel, sugar maple, basswood and spreading dogbane.

Square yard samples taken in an alfalfa field on the Bruce peninsula indicated an average population of 132 per acre. This species was also common in the Camp Borden area.

TABLE II.—Flower-visiting rate and tripping efficiency of the *Megachile* in southern Ontario.

Species	Flowers visited per minute	Tripping efficiency in per cent
<i>M. brevis</i>	16-20	99-100
<i>M. texana</i>	18-22	100
<i>M. centuncularis</i>	26-28	99-100
<i>M. inermis</i>	16-22	95
<i>M. relativa</i>	—	—
<i>M. frigida frigida</i>	20-26	100
<i>M. melanophaea melanophaea</i>	13-16	100
<i>M. latimanus</i>	19-28	99-100
<i>M. pugnata pugnata</i>	—	—

*Megachile* (*Megachile*) *centuncularis* (Linn.) is reported to be Holarctic and in North America its range extends from coast to coast but it is typically more northern in distribution. Nests were taken from the soil and from mud cells on the rafters of a house by Gentry in 1874 (Mitchell, 1934).

In 1951, a single female was found on sow thistle at Guelph. In 1952, a few specimens were observed on alfalfa at Cayuga.

*Megachile* (*Megachile*) *inermis* Prov. occurs throughout North America except in the south-eastern States. Sladen (1919) found a nest of this species in rotting apple wood, and specimens were reared from logs by Peck and Bolton (1946). The latter workers reported the species to be a slow tripper of alfalfa as compared with other leaf-cutting bees in northern Saskatchewan.

Near Creemore, specimens observed on alfalfa, visited 16–22 florets per minute while two other species in the same field visited from 19–22 florets per minute. Nests of this species were not found during the present study but a single specimen was observed to cut leaves from fireweed. In general, *M. inermis* was relatively common in most parts of Ontario visited but it was seldom found on alfalfa.

*Megachile (Megachile) relativa* Cress. has been recorded from North Carolina to California and northward throughout southern Canada. It was reported by Peck and Bolton (1946) to be a fast and efficient tripper of alfalfa but that observations were difficult since it was easily frightened in the field.

Hicks (1926) reared specimens from cells taken from a tunnel in a bank. Mitchell (1936) suggested that it may also nest in logs. A very few specimens were taken during the present study but none were observed on alfalfa.

*Megachile (Delomegachile) frigida frigida* Sm. is found throughout Canada, Alaska, and the northern portions of the United States. In Ontario the species was most common in Bruce and Simcoe counties but it was found also in some of the more southern counties. It is an active and efficient tripper of alfalfa. Peck and Bolton (1946) considered this species to be the most abundant of the wild pollinators in northern Saskatchewan.

*M. frigida* was observed nesting in the soil and in decaying wood during the present study. One piece of wood, about 3 inches in diameter and 2 feet long, contained 26 cells. The nests in the soil were under stones and under the basal leaves of small plants. These consisted of a single cell each or occasionally two cells.

Females were observed to cut leaves of young basswood and sugar maple trees.

*Megachile (Delomegachile) melanophaea melanophaea* Sm. is widely distributed throughout North America. In Ontario they were not found in the more southerly counties. Specimens first were seen in 1952 on alsike near Atwood. On the Bruce peninsula this species was very common and it was seen on flowers of alfalfa, red clover, sweet clover, St. John's-wort and cinquefoil.

Females were observed to cut leaf-pieces from wild cherry and sugar maple. They were most active during the latter part of June and the first three weeks of July. Specimens were rarely seen after the first week of August.

*Coelioxys rufitarsus* is recorded as a parasite of the species.

*Megachile (Xanthosarus) latimcenus* Say is found east of the Rockies in Canada and in the more northerly regions of the United States. Sladen (1918) observed *M. perihirta*, a closely related species, nesting gregariously in a new and bare gravel railway embankment in northern Ontario. Mitchell (1936) reported *M. latimanus* nesting in the soil, and a small seedling oak was the probable leaf source. One specimen was found nesting in bare, gravelly soil at Guelph in 1952.

This species is the most common of the *Megachile* in southern Ontario. Most alfalfa fields had a few of these active pollinators. Females were observed to cut leaf-pieces from climbing false buckwheat and sugar maple.

*Megachile (Sayapis) pugnata pugnata* Say is widely distributed throughout the United States and southern Canada. The species was found only occasionally in southern Ontario and here as elsewhere, alfalfa did not serve as a food plant.

#### BEES OF THE GENUS ANDRENA

These solitary bees are among the more common of all bees in southern Ontario but only one species *A. wilkella* (Kby.) was associated with alfalfa in the period of this study. Specimens were observed on first-stand alfalfa at Guelph in 1951. Flower-visiting rates are shown in Table III.



In 1952 a first-cut alfalfa field near London and another at Listowel, were studied and each had a population of 1 bee per 12–15 square yards. In some parts of the Province this species may be of major importance in pollinating first-stand alfalfa, as its activity period is from the middle of May until about the end of July.

#### BEEES OF THE GENUS ANTHOPHORA

*Anthophora (Clistodon) furcata terminalis* Cress. was reported as an important pollinator of alfalfa in the Ottawa area by Sladen (1918). Peck and Bolton (1946) stated that it was a common visitor to alfalfa in Saskatchewan but was not an efficient tripper. The species was abundant in areas of Dufferin and Bruce counties in Ontario and was often found in alfalfa fields (Table III).

Nests were found only in wood that had undergone considerable decomposition and was relatively soft. Intensive farming practices in the more southerly counties could well cause a serious diminution in the population of this bee. The removal of old stump and rail fences and the dead trees from wood lots has destroyed the nesting sites of the bee in many areas.

TABLE III.—Flower-visiting rate and tripping efficiency of *Andrena*, *Anthophora* and the family Halictidae on alfalfa in southern Ontario.

Family	Species	Flower visits per minute	Tripping efficiency in per cent
Andrenidae	<i>Andrena wilkella</i>	11–18	40–60
Apidae	<i>Anthophora furcata</i>	14–17	30
Halictidae	<i>Lasioglossum athabascense</i>	11–13	1–25
	<i>L. stultum</i>	3–8	Occasional blossoms
	<i>Augochlora pura</i>	3–9	" "

#### BEEES OF THE FAMILY HALICTIDAE

This family of bees is well represented in southern Ontario and many species are commonly found on red and sweet clover. A few species were present in most alfalfa fields visited. Some of these were of value as tripping agents while others visited tripped blossoms only.

*Lasioglossum athabascense* (Sandh.) was observed in the alfalfa fields on the Bruce peninsula. Its flower-visiting rates are given in Table III. This species was also observed to visit tripped blossoms. *Augochlora pura* (Say), *Augochlora striata* (Prov.), and *Lasioglossum stultum* (Cress.) were abundant in many alfalfa fields but visited tripped blossoms only. Englebert (1932) collected *Lasioglossum albipenne* (Robt.) from alfalfa and reported *Halictus provancheri* (= *confusus* Sm.) as tripping alfalfa.

It is evident, at least for the species mentioned, that the halictine bees will not contribute greatly to the tripping of alfalfa florets. Their principal contribution is probably the pollination of many of the flowers tripped by other agencies.

#### THE EFFECTS OF WIND, RAIN AND ARTIFICIAL TRIPPING ON SEED PRODUCTION.

Heavy rains and strong winds appeared to contribute little to the tripping of alfalfa in southern Ontario, during the present study. Tysdal (1946) reported that in some fields, rain caused about 7 per cent tripping but considered it detrimental since cross-pollination was effected. In such instances the small halictine bees would contribute greatly to seed production by visiting and cross-pollinating blossoms tripped in this manner:

Artificial tripping has received considerable attention from Carlson (1930), and others. The alfalfa blossoms were effectively tripped (30—40 per cent) in one field, near Georgetown, in 1951, by dragging a large rope over the plants. The negative results were the same as those reported by Lejune and Olson (1940), and Silversides and Olson (1941) in Manitoba. Large scale tripping by artificial means is not recommended as a means of producing seed.

#### DISCUSSION

There are probably over 200 species of bees in Ontario. The majority are of importance to wild plants but a considerable number have much value in the pollination of cultivated crops. Bohart (1952) stated that over 100 species of bees have been reported as visitors to alfalfa flowers. At least 30 species were found visiting alfalfa in southern Ontario. Several species of bees recorded from alfalfa in other areas of America were found to be present in Ontario but were not observed on alfalfa during the present survey. Among these were *Agapostemon* spp., *Hylaeus* spp., *Calliopsis andreniformis*, *B. rufocinctus*, and *M. relativa*.

Among the bees, social life is the exception rather than the rule, with bumblebees and honeybees being the only social forms in the Nearctic region. The nesting habits of bumblebees are quite well known and, in general, well-protected cavities above or below the ground are selected. Many of the nests observed during this study were in old mouse nests. Most species of bumblebees in Ontario are of some importance in alfalfa pollination. The species and number of individuals will vary from one district to another but where there is limited competitive bloom as well as a limited acreage of alfalfa for seed, they will be responsible for much of the pollination.

The great majority of the bees in Ontario are solitary and nest in the soil or in wood. Among these are the *Megachile*, which are considered to be the principal pollinators of alfalfa seed crops in Canada (Bohart, 1952). They were certainly the most efficient pollinators of alfalfa in Ontario during 1951-52. With few exceptions, however, in the fields under observation the leaf-cutting bees were not sufficiently abundant to set profitable seed yields. They were most numerous in parts of Bruce, Grey and Simcoe counties where there is much land that has never been cultivated. Here the wild bees have not been disturbed and alfalfa probably produces seed more consistently than elsewhere in southern Ontario.

In the London and Listowel areas, several fields of alfalfa had profitable seed-sets in 1952. Observations were not made until close to the end of the bloom-period. Field samples at this time indicated a population of *Andrena wilkella* of 1 bee per per 12—15 square yards. Using the Carlson *et al* standard it is evident that this andrenid was present in sufficient numbers to produce worth-while seed yields.

Automatic tripping is said to occur during hot, dry weather. If such is the case cross-pollination might be accomplished through the activity of several species of small halictids that visit tripped blossoms only.

Alfalfa is visited by many kinds of bees but only the pollen-gatherers deliberately trip the blossoms. In most parts of Ontario studied, the number of wild bees was insufficient to pollinate the acreages of alfalfa devoted to seed production. In areas such as Haldimand county, legumes are grown principally for green or cured forage. The majority of land is under cultivation or pasture and the amount of wild land represents a small percentage of the total acreage. In the areas further north in Bruce, Grey, and Simcoe counties, there is considerably more wild land and, as one might expect, a much greater wild bee population.

In the alfalfa fields surveyed on the Bruce peninsula there were no honeybees. It was possible to observe as many as 17 species of wild bees engaged in pollen-gathering in a single field. During the present study the most consistent seed sets were in fields where the wild pollinator population was made up of many species. Any one species may have its limitations depending upon the general weather and climatic conditions, parasites, predators, nesting sites, spring and fall food sources, etc.

In areas of the province that are extensively farmed and where land values are high, it is unlikely that legume seed yields will ever be satisfactory under existing conditions. In those parts where poor land or unsuitable topography limit the extent of cultivation, the wild bees can be conserved and probably increased. A continuous supply of pollen and nectar plants appears to be one of the most important factors in the stabilization of bee populations. Wild bees depend upon daily foraging to maintain their brood or to provision the cells of their nests. A limited food supply will cause a reduction in the numbers of young bees in the following year. Natural bloom is limited during the summer months and leguminous crops probably provide much of the pollen and nectar required by the bees at this time. The simultaneous cutting of first- or second-stand leguminous crops in any one area may bring about a serious food shortage.

The merits of honeybees in general pollination are not being overlooked but the effect of their foraging activities on the less efficient foragers, should be investigated. Their value in alfalfa seed production in Ontario has not been demonstrated. The tripping efficiency of the honeybee was reported by the Department of Apiculture as .76 per cent. Pearson (1933) concluded that they cause a serious diminution in the food supply of native bees. Peck and Bolton (1946) expressed the opinion that keeping honeybees on a large scale may be a threat to the growing of alfalfa seed.

### CONCLUSIONS

The information accumulated during 1951-52 indicates that the major portion of alfalfa pollination in the areas surveyed is accomplished by wild bees. Since tripping and cross-pollination are primary factors in seed production, seed growers must be made aware of the importance of these bees and of the need for their conservation. Injurious insects, soil and other conditions become limiting factors in seed production only when there is an adequate population of wild pollinators in the area.

Bumblebees are important pollinators of alfalfa in parts of the Province where there are limited acreages of leguminous crops and other competitive flowering plants. Intensive and extensive farming practices may have reduced the numbers of bumblebees but it is more probable that species, which nest in or near wooded areas, have been replaced by those that nest in the open or adapt themselves to living in farm buildings.

Bees of the genera *Megachile*, *Andrena*, and *Anthophora* and of the family Halictidae are among the more important solitary bees. Their effectiveness in pollinating alfalfa will depend upon weather and competitive pollen and nectar sources. Warm, dry conditions are the most favorable for bee activity.

The *Megachile* or leaf-cutting bees are the most efficient of the wild pollinators of alfalfa and to them the credit should go for most of the alfalfa seed produced in Canada. Their nesting habits have made them especially vulnerable to cultivation and changing farm practices. During the present survey it was evident that the number of *Megachile* varied greatly from one area to another. The general decline in seed production then may be due to a reduction in the number of solitary bees and to the great increase in the acreage of alfalfa. The high seed-producing fields of the first quarter of this century were never studied and one can only guess as to the population density of wild bees during that period.

*Megachile*, as mentioned previously, are the most efficient pollinators of alfalfa and certainly the most variable in numbers in the areas of Ontario surveyed. Biological and ecological information on this group of bees is meagre. When we fully understand their habits and know their requirements it may be possible to increase their numbers through a modified cultural programme.



## SUMMARY

The most important pollinators of alfalfa in southern Ontario are the wild bees of the genera *Bombus*, *Megachile*, and *Andrena*. Small halictine bees are of value under certain conditions and a few of the larger species are of importance in some areas. A continuous supply of food plants throughout the growing season is necessary for maximum development of the bumblebee colonies and maximum nest-building activities of the solitary forms. The most common early flowering plants in Ontario are the flowering trees and dandelions. The bloom period of the trees is short and consequently the dandelions provide the major part of the food for the early bees. The *Megachile* emerge after the middle of June and are dependent on *St. John's-wort*, cinquefoil and ox-eye daisy.

Communities of competing pollen sources often grow in close proximity to some alfalfa seed fields. The most attractive of these are blueweed, chicory, thistles, sweet clover and red clover. The cutting of alfalfa and red clover hay crops when their bloom period coincides with that of the seed crop, and the cutting of communities of wild flowering plants at the same time, will tend to restrict the available pollinators to the desired crop. The bloom period of alfalfa can be timed to coincide with the peak of the pollinator population. This however, will vary with the kinds of bees present. An appraisal of the species of wild pollinators in each district is necessary before any modifications in cropping practices can be made.

In general, the populations of wild bees are insufficient to pollinate the acreage of alfalfa devoted to seed production. Present farming practices do not favour an increase in bee numbers and any attempt to bring this about will be well worth while. The introduction of different species of bees from other areas may have possibilities but the re-establishment of native bees by means of an intelligent programme offers much more promise.

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## SUMMARY OF IMPORTANT INSECT INFESTATIONS, OCCURENCES, AND DAMAGE IN CANADA IN 1953<sup>1</sup>

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This summary of insect conditions was prepared from regional reports submitted by officers of the Entomology Division, provincial entomologists, officers of the Plant Protection Division, and university professors. In general, common names used are from the 1950 revision of the list approved by the American Association of Economic Entomologists. Common names other than these are accompanied by technical names. To avoid unnecessary duplication, forest insect conditions are not included, this insect group being adequately dealt with in the *Annual Report of the Forest Insect and Disease Survey*, published by the Forest Biology Division, Canada Department of Agriculture.

The summary of weather conditions was compiled from reports submitted by officers of the Entomology Division, and from seasonal federal and provincial crop reports. The crop production summary was taken from the "November Estimate of Production of Principal Field Crops, 1953", Dominion Bureau of Statistics. Crop data for Newfoundland were not available. The figures on honey production were obtained from officers of the Bee Division, Experimental Farms Service, Canada Department of Agriculture.

### WEATHER CONDITIONS AS AFFECTING CROPS AND INSECT PESTS IN CANADA, 1953

The winter of 1952-53 was mild throughout Canada, February in particular being a very mild month.

In British Columbia, precipitation was normal to above normal in most coastal and extreme southwestern areas, but light in interior regions. The light snow cover in the interior disappeared quickly, permitting early seeding but leaving poor reserves of moisture and a threatened shortage of irrigation water in some districts. However, the weather during April and June was cool and wet, and the light rainfall in May was uniformly distributed and reasonably effective on plant growth. As a result of early planting and satisfactory rainfall, growth was good in all crops and normal or a little earlier than average. Cereal crops were well above average growth; fodder crops were heavy, but poor harvesting conditions during June delayed cutting beyond the time of high quality, or caused deterioration and in some cases complete loss. Adverse weather conditions delayed the development of tomatoes, but freedom from early killing frosts in most areas resulted in yields that were above normal. In the Kamloops area, mild weather continued well into November.

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After the unusually mild winter in Alberta and Saskatchewan, spring seeding was greatly retarded by low temperatures, a blizzard and severe frost in mid May, and rainfall much in excess of normal. Local flooding caused crop losses in some areas. Hail damage, too, was greater than usual. Subnormal temperatures persisted until early August in Alberta, but damaging frosts did not occur until late in September, permitting most late-seeded and retarded crops to mature. Frequent showers hampered harvest operations for a time in both provinces, but these were followed by a lengthy period of ideal harvest weather, and most crops were threshed and stored in good condition. Climatic conditions apparently favoured wireworm activity in western areas of Saskatchewan, where damage was more severe than usual. In northeastern agricultural areas of the Province alfalfa did not bloom until the latter part of July and insect development was correspondingly late. Above-normal temperatures during the fall favoured oviposition by grasshoppers, and the continuation of damage by the greenbug well into November.

In Manitoba, precipitation was above average in the Brandon area, but below average in southern and eastern districts. In the latter regions seeding was delayed on this account. Strong winds caused some soil drifting, especially in the Red River Valley. High temperatures in late April and early May stimulated growth, but the heavy snow and frosts, which affected the whole prairie area in mid-May, froze the leaves of some deciduous trees, including poplar and maple. Garden and field crops, however, were not seriously damaged. Very heavy rains in southern Manitoba in June caused some flooding, delayed seeding, and resulted in heavy weed growth. The acreage of grain crops was reduced and that of flax increased. Good growing conditions continued and fine fall weather permitted the harvesting of excellent crops except of durum wheat, yields of which were reduced by rust. Weather conditions caused a further reduction in grasshopper populations, and damage by cutworms and other injurious insects was of minor importance. Aphids, however, were very injurious to field peas and other vegetation.

In Ontario, most crops wintered well except in Carleton and Renfrew counties, where 30 per cent loss of legumes was reported. Winter-killing of fall wheat averaged 6 per cent and of rye 3 per cent in the Province as a whole. Unusual infestations of the tobacco hornworm and some other insect species in extreme southwestern areas were believed to have been a result of the unusually mild winter. Seeding started early in most districts, but cool, wet weather in the latter part of April retarded planting and plant growth generally. Except for a short, warm, dry period in May, adverse conditions prevailed in most of southern Ontario well into the summer. As a result, spring grain was reported to be only 70 per cent seeded in the most southerly areas of the Province, 85 per cent in west-central areas, 88 per cent in south-central areas, and 95 per cent in the east. Spring seeding was completed in northern districts. Some crop losses resulted from excess moisture in low areas and in heavy soils. Pastures generally remained in good condition during most of the summer. Hay crops were very good in western and central areas and average in eastern and northern districts, but frequent rains interfered with haying operations and adversely affected the quality in some districts. Growth of all crops was excellent in August, but lack of moisture late in the month and during the first half of September reduced yields of truck crops and fruit. Ideal conditions for harvesting prevailed from August 10 to September 10 in most areas, and heavy rains in mid September improved pastures and late crops.

Winter and spring conditions in Quebec were comparable to those in Ontario, but lower precipitation permitted completion of seeding by May 25 in all areas except the Gaspé and Saguenay regions. Dry conditions continued into July, seriously affecting hay, pastures, and early vegetables in all areas except the Eastern Townships. Rains during the latter part of July improved grain yields, and pastures, but were too late to help the hay crop. August was comparatively dry and cool, reducing yields of late crops somewhat and adversely affecting pastures. Harvest weather was generally favourable and the grain crop was stored in good condition.

In the St. Lawrence Gulf region, frequent rains reduced the snow cover very early, resulting in severe winter-killing of susceptible crops in many areas, especially in New Brunswick and Nova Scotia. Heavy rains in late May and subnormal temperatures in early June delayed seeding in most districts and retarded plant growth. The hay crop was light in New Brunswick

and, as a result of cool, wet weather in July, was still being harvested in August in an over-mature condition. This weather also adversely affected emergence of root maggot adults and oviposition was light. Severe outbreaks of the armyworm and the corn earworm in both New Brunswick and Nova Scotia may have resulted, in part, from the mild winter. Weather conditions were favourable, too, for the buckthorn aphid, which occurred on potato in outbreak numbers in New Brunswick. Growing conditions were good during the summer in Prince Edward Island, resulting in excellent crops. In the entire Gulf area the unusually mild winter was suitable to the survival of overwintering insect life, and was followed by some unusual infestations.

Near-record above-average crop yields were made possible by generally favourable harvesting conditions, particularly in the Prairie Provinces, and by the absence of early killing frosts in those areas where unusually late seeding left crops susceptible to potential frost damage.

#### CROP PRODUCTION SUMMARY FOR CANADA, 1953

For the third successive year, Canadian farmers harvested unusually large grain, oilseed, and fodder crops. Although new production records were set for only one crop, soybeans, five other crops — wheat, barley, rye, shelled corn, and rapeseed — were the second largest on record. Production figures for 10 of the 20 crops for which estimates are included in this report were above the record or near-record levels reached in 1952. Spring wheat, oats for grain, barley, spring rye, mixed grains, and flaxseed were among the 10 crops for which reduced returns were indicated.

The November estimate of the production of grain crops in Canada in 1953 was, in bushels, as follows, with the 1952 production in parentheses: wheat, 613,965,000 (687,922,000); oats for grain, 405,580,000 (466,805,000); barley, 262,065,000 (291,379,000); rye, 28,149,000 (24,557,000); mixed grains, 62,087,000 (63,205,000); shelled corn, 20,854,000 (19,722,000); buckwheat, 3,161,000 (2,680,000); peas, dry, 1,207,800 (888,500); beans, dry, 1,219,000 (1,292,800); flaxseed, 10,412,000 (12,961,000); soybeans, 4,406,000 (4,128,000).

Root and fodder crop production with the 1952 figures in parentheses, was estimated as follows: potatoes, 66,469,000 (60,071,000) bushels; field roots, 484,000 (495,000) tons; tame hay, 19,868,000 (19,083,000) tons; fodder corn, 3,546,800 (3,798,200) tons; sugar beets, 898,374 (1,022,693) tons.

Almost without exception, average yields per acre of spring-sown grains were higher than in 1952 in Eastern Canada and British Columbia, and below the 1952 record or near-record levels in the Prairie Provinces. Average yields of fall-sown grains, with the minor exception of fall rye in Quebec, were above those of 1952. Record average yields per acre were established for wheat in New Brunswick, Quebec, and Ontario; for oats in Prince Edward Island; for fall rye in Ontario, Manitoba, and Alberta; for mixed grains in Nova Scotia and Quebec; for buckwheat in New Brunswick; for potatoes in British Columbia and Canada as a whole; and for rapeseed in Saskatchewan.

**WHEAT.**— Canada's 1953 wheat crop, estimated at 614.0 million bushels, was second only to the 1952 record of 687.9 million, and 45 per cent above the ten-year (1943-1952) average of 423.5 million bushels. The 1952 and 1953 wheat crops were not only the only two in excess of 600 million bushels, but they followed a crop of 562.7 million in 1951. Before 1951, only four Canadian wheat crops — those of 1928, 1939, 1940, and 1942 — had exceeded the half-billion bushel level and only two of those, in 1928 and 1942, were greater than 550 million bushels.

The 1953 crop of spring wheat, estimated at 587.8 million bushels, was harvested from a seeded area estimated at 24.8 million acres and yielding 23.7 bushels per acre. In 1952 the spring wheat crop yielded a record average of 26.3 bushels per acre. Production of winter wheat in Ontario, the major producing area for this crop, was estimated at 26.2 million bushels, harvested from 732,000 acres averaging a record yield of 35.8 bushels per acre. The estimated average wheat yield for the Prairie Provinces was 23.7 bushels per acre, Manitoba averaging 20.8 bushels per acre; Saskatchewan, 23.3; and Alberta, 25.7. The Saskatchewan crop, estimated at



375 million bushels, was second only to the 1952 record of 435 million. Production in Alberta was placed at 163 million bushels, 9 million below the 1952 crop. In Manitoba the crop was estimated at 46 million bushels as against 57 million in 1952.

**OATS.**— Production of oats for grain was placed at 405.6 million bushels, down 13 per cent from the 1952 crop of 466.8 million, largely as a result of a smaller seeded acreage. The average yield, at 41.3 bushels per acre, was less than a bushel below that of 1952. Both average yields and production exceeded those of 1952 in all areas except the Prairie Provinces. However, the reduction in these provinces from the 1952 crop of 346 million bushels to 276 million more than offset increases elsewhere.

**BARLEY.**— The barley crop, estimated at 262.1 million bushels, was second only to the 1952 record crop of 291.4 million. Average yields per acre exceeded those of 1952 except in the Prairie Provinces. Production there was estimated at 251 million bushels, 30 million less than the 1952 record, Alberta accounting for 108 million bushels; Saskatchewan, 82 million; and Manitoba, 61 million.

**RYE.**— The combined production of fall and spring rye was placed at 28.1 million bushels, surpassed only by the record 32.4 million bushels harvested in 1922. Production of fall rye, estimated at 20.6 million bushels, was some 39 per cent above the 1952 crop of 14.8 million, but spring rye, at 7.5 million bushels, was about 23 per cent below the 9.8 million harvested in 1952. All but 1.9 million bushels of the rye crop was grown in the Prairie Provinces.

**OILSEEDS.**— Excepting flaxseed, production of oilseed crops for which estimates were available was above that of 1952. Flaxseed production, estimated at 10.4 million bushels, was down from 13.0 million in 1952 as a result of a decrease of 14 per cent in seeded acreage and a drop in average yields per acre from 10.7 to 10.1 bushels. The flaxseed crop in the Prairie Provinces was placed at 9.8 million bushels, of which Manitoba accounted for 4.5 million. Soybean production, currently confined to Ontario, set a new record of 4.4 million bushels, almost 300,000 bushels greater than in 1952.

**Rapeseed** production, estimated at 51.5 million pounds, was more than three times as great as in 1952, and was second only to the record 85.6 million pounds harvested in 1948. The sharp increase was a result of increases in both acreage and average yields. In Saskatchewan, the major producing area, the crop was estimated at 48.1 million pounds, an average of 1,300 pounds per acre. Manitoba's outturn was placed at 3.4 million pounds, an estimated 750 pounds per acre. Production of sunflower seed in Manitoba, currently the only province growing this crop commercially, was estimated at 4.0 million pounds as against 1.9 million in 1952.

**MIXED GRAINS.**— Production of mixed grains, grown principally in Eastern Canada, was placed at 62.1 million bushels, 1.1 million below that of 1952. Average yields were higher in all provinces except Saskatchewan and Alberta and the average for Canada was 43.0 bushels per acre as against 40.3 in 1952. The reduction in the seeded area from 1.6 million to 1.4 million acres more than offset the effect of increased average yields.

**DRY PEAS AND BEANS.**— Production of dry peas was estimated at 1,207,800 bushels as against 888,500 bushels in 1952, and the dry bean crop was placed at 1,219,000 bushels, slightly below the 1952 yield of 1,292,800 bushels. Acreages seeded to both crops were higher than in 1952 but average yields were lower.

**SHELLED CORN.**— Production of shelled corn, estimated at 20.9 million bushels, was the largest since 1908 and 1.1 million greater than in 1952. Excepting an estimated 450,000 bushels in Manitoba, all of the crop was produced in Ontario.

**POTATOES.**— The potato crop, estimated at 66.5 million bushels, was 6.4 million greater than in 1952. Increased acreages in all provinces except Saskatchewan and Alberta, and greater average yields in all but these two and Ontario and Prince Edward Island, contributed to the over-all increase over 1952. The total average yield, estimated at 207 bushels per acre, was the highest on record.

**SUGAR BEETS.**— Production of sugar beets in the four beet-growing provinces was placed at 898,000 tons as against 1,023,000 in 1952. Reduced yields occurred in all provinces except Manitoba, where both acreage and average yield were above those of 1952. In Alberta, the major producing area, the crop was estimated at 422,000 tons, accounting for about 47 per cent of the total.

**FORAGE CROPS.**— Total production of tame hay (including clover and alfalfa) was estimated at 19.9 million tons, compared with 19.1 million in 1952. The heavy hay crop in Ontario, estimated at 7.4 million tons and averaging 2.1 tons per acre, was the chief factor in the over-all increase, since production in all other provinces except Manitoba and Alberta was below that of 1952. The fodder corn crop was placed at 3.5 million tons, down from 3.8 million in 1952, largely a result of lower acreage and yields in Ontario, where the bulk of this crop is grown.

**OTHER CROPS.**— Production of buckwheat, grown chiefly in Ontario and Quebec, was estimated at 3.2 million bushels as against 2.7 million in 1952. The crop of field roots (turnips, mangels, etc.) grown in Eastern Canada for livestock feed was placed at 484,000 tons, compared with 495,000 tons in 1952.

**HONEY.**— Honey production, according to preliminary estimates, was 26,100,000 pounds during 1953 as compared with the ten-year average of 37,249,500 pounds for all of Canada. The 30 per cent reduction, on the average, was largely due to lower production in Ontario. The western province had near- or above-average honey crops in 1953.

#### GENERAL—FEEDING AND MISCELLANEOUS INSECTS

**BEET WEBWORM.**— This insect was very scarce in the Prairie Provinces, damaging populations being limited to a few isolated fields in the Cranford and Coaldale areas in Alberta.

**BLISTER BEETLES.**— In British Columbia, blister beetles caused very little damage in the Okanagan Valley, and at Ashcroft and Kamloops infestations on alfalfa and tomato were less general than in 1952. *Meloe* sp. was unusually abundant in northern Alberta, infesting clematis, potato, and aster, and being reported as far north as Fort Norman. No damage was reported in Saskatchewan. Larvae of *Epicauta subglabra* (Fall) and *E. fabricii* (Lec.) fed on grasshopper eggs in about the same numbers as in 1952, in the restricted areas of the Red River Valley in which grasshoppers were abundant. *E. pennsylvanica* (Deg.) caused severe local damage to potatoes near Doaktown, N.B.

**CRICKETS.**— A localized infestation of the coulee cricket was again present in the Vernon, B.C., area, but elsewhere throughout Western Canada crickets, in general, were scarce.

**CUTWORMS.**— In British Columbia, cutworm damage, in sharp contrast to 1952, was negligible in the lower Fraser Valley and on Vancouver Island. In the Okanagan Valley, some serious damage to small fruits was reported. In the interior, the black army cutworm occurred in outbreak numbers in many areas. Those mainly affected included: St. George east to McBride; the North Thomson Valley south to Kamloops, thence east to Salmon Arm and Armstrong; and in the east Kootenay at Edgewater, Golden, Fernie, Cranbrook, and Elko. Forage crops suffered the greatest damage, but cereals also were attacked. The redbacked cutworm, too, occurred in outbreak proportions over much of the interior, but damage to field and truck crops was not as extensive as in 1952.

In northern agricultural areas of Alberta, cutworms caused little damage, although for the first time since the outbreak of 1926-31 the bertha armyworm caused local damage of economic importance, chiefly to cabbage, in several gardens in the Edmonton area. Damage by the pale western cutworm was limited to light, patchy infestations, mainly in the east-central part of the Province. The only outbreak requiring control measures was confined to a relatively small heavy-soil area in the Acadia Valley. Because of heavy rains in May and June, this cutworm species is not expected to be numerous in other areas of the Province in 1954. A severe outbreak of the black army cutworm occurred in the Elk Valley, near Crowsnest Pass, severely defoliating alfalfa and clover. It was found also at the Lacombe Experimental Station, where it damaged red fescue.

In Saskatchewan, the pale western cutworm was less abundant than for many years. In central and western agricultural areas, it occurred in small numbers in one or more fields at Dundurn, Floral, Prud'homme, Battleford, Rosetown, Stranraer, Cabri, and Burstall, but damage was light and adults were very scarce in the fall. The bertha armyworm occurred in the largest numbers since 1948, but damage was negligible. Larvae were found in half of the fields in the three major rape-growing areas, at Shellbrook, Birch Hills, and Tisdale; and at Langbank in southeastern Saskatchewan flax was extensively infested. The red-backed cutworm caused very little damage. A small plot of oats was destroyed in the Pas Trail district, and although larvae were found in half of the cropped fields examined in the Richard-North Battleford-Cando area, damage did not exceed 5 per cent in any field. Small numbers of larvae were present in a few fields at Aberdeen, Vonda, and Saskatoon, but no damage was apparent. Vegetables were damaged in a few gardens at Saskatoon, and at Blucher one garden suffered 25 per cent damage. A climbing cutworm, *Chrysoptera moneta* (F.), again damaged delphinium in a garden at Saskatoon.

In Manitoba, the outbreak of 1952 did not continue in 1953 and very little damage occurred. The red-backed cutworm was troublesome in gardens in southwestern Manitoba, and severely damaged sunflowers in a plot at Melita. The pale western cutworm was present in the area north of Brandon, but no damage was reported. Neither the armyworm nor the bertha armyworm was reported, and the army cutworm was not abundant. At Altona, cutworm moths were numerous on sunflower blossoms in August.

In Ontario and Quebec, no unusual cutworm damage was reported, except in Essex County, Ont., where tomato transplants in the canning areas were attacked more severely than in recent years. All early muck-soil crops, particularly lettuce, were extensively damaged in the Holland Marsh area in south-central Ontario. North of Lake Ontario, damage was less severe than in 1952, and somewhat below average in the Ottawa, Ont., district. The armyworm was not found in southwestern Ontario, although reported to be abundant in some adjacent areas of the United States. The w-marked cutworm and the spotted cutworm were reported from Rougemont, Que., where they damaged up to 50 per cent of windfall apples in some orchards. Cutworms were prevalent and somewhat injurious throughout Quebec, but no serious outbreaks were reported.

The armyworm occurred in outbreak numbers in parts of New Brunswick, and was the outstanding pest of the season in Nova Scotia. In New Brunswick it caused major damage to oats in Carleton, Victoria, and Charlotte counties, and attacked timothy in an orchard in Westmorland County. In Nova Scotia, the outbreak, the most severe since 1937, occurred in Antigonish, Colchester, Cumberland, Halifax, and Hants counties. Damage to field crops, however, was restricted in extent and not very severe. As in 1937, the outbreak followed a mild winter. Severe cutworm damage was reported from the French Lake, N.B., area, and adults of the black army cutworm were observed in considerable numbers. *Euxoa* spp. were moderately numerous in the Annapolis Valley, N.S., and the fall armyworm occurred in most corn fields in the Province, but damage was believed to be less than in 1952. In Prince Edward Island, the armyworm caused severe injury in a grain field; no damage by the red-backed cutworm was reported, and the variegated cutworm was present in the lightest infestation in years. In Newfoundland, two small infestations of the armyworm in the Codroy Valley and in St. John's Extern caused some damage to grain. The black army cutworm, less numerous than in 1952, occurred in minor outbreaks in the St. John's West farming area. Infestation and damage were mainly light throughout the Province.

**EARTHWORMS.**— A large population of *Lumbricus terrestris* L. caused a 20 to 40 per cent reduction of approximately 20,000 tomato seedlings in the seed-bed near Chatham, Ont. These unusual losses were due to the earthworms either feeding on the seedlings or pulling them into their burrows. Earthworms were particularly abundant in surface soil in southwestern Ontario because of the long, cold, wet spring.

**EUROPEAN EARWIG.**— This pest is reported to have been more troublesome than ever before in British Columbia. It was particularly injurious to carrot, potato, corn, celery, dahlia, chrysanthemum, and marigold on Vancouver Island and in the lower Fraser Valley, and to



apricot and peach in the Peachland and Westbank areas. Infestations in both homes and gardens were numerous in the Okanagan and Kootenay valleys. It continued to spread in Bruce and Gray counties, Ont. In Nova Scotia it was found for the first time, having become established in several blocks in the dock area at Yarmouth; it is believed to have been transported from St. John's, Nfld., where it has been present for several years and continues to spread.

**GRASSHOPPERS.**— Grasshoppers were numerous in the Fort Providence and Fort Simpson areas of the Northwest Territories; adult specimens received at Saskatoon, Sask., were identified as of *Melanoplus mexicanus mexicanus* (Sauss.), and nymphs appeared to be of *M. bruneri* Scudd.

In British Columbia, the coastal areas and the territory north of Alexandria, Louis Creek, Sicamous, Balfour, Fort Steele, and Roosville were comparatively free of infestation, but elsewhere in the Province grasshoppers were again a serious problem. *Camnula pellucida* (Scudd.) and *M. m. mexicanus* were the species of major importance, but *Melanoplus femur-rubrum* (Deg.) was the most numerous species in orchards and other irrigated crops in the Okanagan and Thompson River valleys. Decreases in abundance were most evident in the Nicola control zone, which was thoroughly sprayed with aldrin in 1952. Only a few of *M. bivittatus* (Say) were present in the Kersley and Quesnel areas, 1953 apparently being a year of diapause.

In Alberta, grasshopper populations were at a very low level everywhere except in the extreme south between Lethbridge and Medicine Hat. Within this strip, populations showed a considerable increase over 1952, reaching 20 to 30 per square yard in some places along the roadsides. *M. bivittatus* and *M. m. mexicanus* were the species present. Very little damage occurred as the populations were mostly limited to the roadsides, where vegetation was heavy after a wet spring. Fewer eggs were laid than normally expected, especially from *M. m. mexicanus*, so that this area rates light in the forecast for 1954. A limited infestation was reported in the Fort Vermilion area of the Peace River district.

The season was generally favourable for grasshoppers over much of western Saskatchewan, but oviposition was so light in 1952 that control measures were not necessary anywhere in the Province during the spring. Favourable weather conditions, however, are believed to have been responsible for a general increase in abundance of adults of *Melanoplus packardii* Scudd. and *M. m. mexicanus*. In an area of severe drought in the extreme southwestern corner of the Province, the two-striped, clear-winged, and lesser migratory grasshoppers together became conspicuous enough to warrant control measures; most of this infestation, however, was only light to moderate. The only egg deposits of economic importance that resulted from this were light to moderate in a very small area along the south shore of Cypress Lake. In comparison with 1952, increases in the abundance of eggs of *M. bivittatus* and *C. pellucida* were noted in the heavy clay soils of the west-central agricultural areas; of *M. packardii* in the light sandy soils of the Saskatoon district; and of *C. pellucida* at a few points near Saskatoon. None of these egg infestations attained economic levels. *M. m. mexicanus*, although widespread, appeared merely to be maintaining itself at a low level of abundance. Grasshoppers, chiefly *M. bruneri*, were common in alfalfa fields in the area from Pas Trail to Smeaton. Heaviest infestations were observed in fields that contained appreciable grass, and several were treated with toxaphene.

Surveys in Manitoba revealed a reduction, as compared with 1952, in populations of *M. bivittatus* and *C. pellucida* in the Red River Valley. Egg hatching was delayed several weeks by wet weather, and infestations varied from a trace to light. *C. pellucida* replaced *M. bivittatus* as the predominant species.

In general, grasshoppers were of minor economic importance in Eastern Canada. Slight population increases were noted, chiefly of *M. bivittatus*, in southern areas of eastern Ontario, where alfalfa was the principal crop affected. Light infestations of *M. femur-rubrum* caused minor, local damage to potatoes at Kemptville, Ont. In Quebec, a rather severe local outbreak of *M. femur-rubrum*, *C. pellucida*, and *M. bivittatus* occurred in the northern part of Portneuf County, causing considerable local damage. No unusual damage was reported from the St. Lawrence Gulf provinces.

**JAPANESE BEETLE.**— The Plant Protection Division, with the co-operation of the Provincial Department of Agriculture, placed some 2800 traps at several points in southwestern Ontario during the beetle flight season of 1953. The total number of beetles trapped was 130, taken at Hamilton, Port Burwell, Fort Erie, Niagara Falls, and Windsor. In addition, one adult was taken in shrubbery in Halifax, bringing the total for the season to 131.

**JUNE BEETLES.**— Local white grub damage to strawberry at Grindrod and to perennials at Vernon was reported from British Columbia. In northern Alberta, potatoes grown on newly broken land were infested. In Ontario, infestation by second-year larvae of *Phyllophaga* spp. in the Niagara Peninsula declined to a new low and little crop damage occurred. Beetle flights were very large over most of southern Ontario, particularly in the Guelph area, and defoliation of host trees was extensive. Damage to raspberry, small shrubs, lettuce, cauliflower, and celery was reported from the Holland Marsh area. Much damage by second-year larvae is forecast for Ontario in 1954. In Quebec, second-year larvae of *Phyllophaga* spp. were abundant in Shefford, Brome, Missisquoi, Huntingdon, Yamaska, Montmorency, and Matapedia counties. In the Ste. Anne de la Pocatière area, damage to potatoes was estimated at 25 per cent of the total crop. *Phyllophaga fusca* (Froel.) and *Diploptaxis* sp. were very numerous in New Brunswick, and a large flight of *Phyllophaga* spp. caused considerable damage in west coast areas of Newfoundland, notably in the St. Georges and Cartville districts.

**A SEED-INFESTING ANT.**— Ants destroyed most of the kernels in a six-acre planting of corn at Bloomfield in Prince Edward County, Ont. Up to a dozen ants were found at a single kernel. No similar experience with the insect in the area was recalled and no explanation for the outbreak was discovered. The seeds in question had been especially slow in germinating.

**TARNISHED PLANT BUG.**— In Manitoba, ornamentals were injured by this species in many localities and chrysanthemums were severely damaged at Morden. Considerable populations were reported throughout Ontario, but in most areas infestations were less severe than in recent years. Damage to celery and lettuce was reported in the Holland Marsh area, to ornamentals in Hastings County, and to a wide variety of crops in Prince Edward County. Moderate to severe damage occurred on celery and ornamentals in the Ottawa area, and light infestations on potatoes were reported from Kemptville, Ashton, and Glasgow Station. In Quebec, large populations, particularly on potatoes, celery, and flowers, were commonly reported. Numbers were noticeably reduced in the St. Lawrence Gulf provinces, but damage to potatoes was reported to be significant in Nova Scotia. In Prince Edward Island and Newfoundland, the insect was of minor importance.

**WIREWORMS.**— Near Agassiz, B.C., an infestation of *Agriotes* sp., believed to be *obscurus* (L.), caused severe damage to a nine-acre field of corn about three miles from the farm on which this species was first found on the mainland of the Province in 1952. Severe wireworm infestations in potatoes were reported from Smithers and the Kispiox Valley (north of Hazelton). *Limonijs canus* Lec. caused localized damage to carrot seed crops at Grand Forks.

Wireworm damage in northern Alberta was below normal, and in southern Alberta no wireworm survey work was done.

In Saskatchewan, damage to grain crops by wireworms, although confined mainly to the western half of the Province, was more extensive and of greater severity than in 1952. Surveys indicated spotty to general light thinning of grain crops throughout the western half and the northeastern areas of the Province. Moderately severe thinning was observed in the Rosetown-Kyle, Chaplin-Elbow, Biggar-Wilkie-North Battleford-Saskatoon, Edam-Turtleford, North Battleford-Glaslyn, and Mennon-Hague-Rosthern areas. Very severe thinning was noted in the Davidson-Girvin-Holdfast, Biggar, Cochin, Glaslyn-Turtleford, Meadow Lake, and Rosthern areas. Extensive use of BHC seed treatments confined the major portion of the serious damage to untreated fields. *Ctenicera aeripennis destructor* (Brown) and *Hypolithus nocturnus* Esch. were equally responsible for most of the thinning of grain crops. *Limonijs pectoralis* Lec. and *Ctenicera aeripennis aeripennis* (Kby.) added slightly to grain injury in northern areas of the Province. As usual, damage was most severe to spring wheat seeded on summer-fallow in medium-

textured soils. However, a larger percentage of grain seeded on stubble was severely damaged than in 1952. Much of the damage occurred as uniform thinning throughout the infested fields. Low-lying areas of many grain fields were more severely thinned than the knolls, which was unusual. Several entire fields and numerous low-lying portions of fields were thinned to the extent that reseeding was necessary. The extent and severity of wireworm damage were attributed to a very noticeable general increase in populations of *H. nocturnus*, apparently a result of moisture and temperature conditions favourable to the reproduction of this species. *H. nocturnus* was found almost exclusively in several fields, and outnumbered *C. a. destructor* in many other fields throughout the damaged areas. The low incidence of wireworm thinning of grain crops in the eastern half of the Province was attributed to exceptionally high moisture conditions during the wireworm damage period.

In Manitoba, *C. aeripennis destructor* caused moderate damage in grain fields at Brandon, Neepawa, Heaslip, Kane, Emerson, Oakville, Carman, Pilot Mound, Dugald, St. Rose du Lac, and St. James. Early-stage larvae damaged wheat kernels before sprouting in a field south of Brandon on May 14.

In Ontario and Quebec, wireworm damage was greater than usual. In southwestern Ontario, where a definite increase was noted, damage to untreated spring grains and corn was extensive. Considerable replanting was necessary in tobacco and tomato crops. Damage to potatoes was widespread, especially in the Ridgeway area. At the Ridgeway potato-grading station, few loads of potatoes were received that were free from wireworm damage. A small field of cucumbers in the Dresden area was ruined by wireworms in July, over 40 wireworms being found around one plant. In Prince Edward County, *Agriotes mancus* (Say) damaged ripe tomatoes resting on the soil, nearly three-quarters of the fruit being injured in one field examined. In Quebec, a general increase in damage, especially to potatoes was reported.

The known ranges of European wireworms in Nova Scotia continued to expand. *Agriotes sputator* (L.) was found several miles inland in the isolated farming community of Riverdale, Digby County; this species develops very dense populations and hence is extremely destructive, being capable of eliminating row crops and seriously reducing hay yields. *Athous affinis* Couper was found associated with *A. sputator* at Marshalltown. *Agriotes obscurus* (L.) infested several fields near Lunenburg and severely damaged oats and potatoes. It was found for the first time at West Hall's Harbour, Kings County. *Agriotes lineatus* (L.) was especially destructive to potatoes near Yarmouth. In the Annapolis Valley, *A. mancus* was apparently normally abundant. *Ctenicera lobata tarsalis* (Mels.) was frequently found. *Cardiophorus gagates* Er. was collected at lights and from soil at Sheffield Mills. In New Brunswick, reports of wireworm damage were received from the Sussex and Taymouth areas.

**NEMATODES.**— The golden nematode, *Heterodera rostochiensis* (Wollenweber, 1923) Franklin, 1940, has not yet been found anywhere in Canada and considerable attention has been given to measures aimed at preventing its introduction.

The sugar-beet nematode, *Heterodera schachtii* Schmidt, 1871, showed no sign of spread from the known areas of infestation.

The oat nematode, *Heterodera avenae* Lind, Rostrup, and Ravn, 1913, continued to present an important problem in Ontario, and corn was added to the list of its hosts.

The situation in regard to other species of *Heterodera* reported previously in Canada remained about the same.

The root-lesion nematodes of the genus *Pratylenchus* showed increasing evidence of being important crop pests, as in other countries. Findings to date indicated that there were at least four or five species of this genus present in Canada. *Pratylenchus penetrans* Cobb, 1917, was the species most frequently encountered and *Pratylenchus pratensis* (deMan, 1880), was not uncommon. All the nematodes of this genus are very small and could be easily overlooked by anyone not well acquainted with them. Furthermore, host preferences are not at all sharply defined.



The reported occurrence of the potato-rot nematode, *Ditylenchus destructor* Thorne, 1945, in the State of Wisconsin focussed renewed attention on this species. On the other hand, apprehension has declined to some degree as knowledge of the pest has increased; it is now recognized that potato cropping will greatly reduce its population.

A root-knot nematode, *Meloidogyne hapla* Chitwood, 1949, was identified from sugar beets near Sarnia, Ont. It was also collected from the roots of tomato at Ste. Genevieve, Que. Further records of root-knot nematodes were reported in the Canadian Insect Pest Review 31 (7), 1953.

Of additional interest was the identification of *Tylenchorhynchus claytoni* Steiner, 1937, from soil around red clover at Ottawa, of *Paratylenchus* sp. from chrysanthemum at St. Catherines, Ont., and of *Trichodorus* sp. from soil around red clover at Ottawa. *Anguina agrostis* (Steinbuch, 1799) Filipjev, 1936, was reported from Prince Edward Island attacking *Agrostis alba* L.

#### FIELD CROP INSECTS

**APHIDS.**— A local infestation of aphids on wheat was reported from Merritt, B.C. In Saskatchewan, the greenbug was as widely distributed and as injurious to fall rye as in 1950. Several thousand acres of this crop were destroyed in the Warman-Rosthern area, and some damage occurred in the Abernethy and Rocanville districts. Fall-seeded cover crops were seriously infested in the Prince Albert-St. Louis area, and late volunteer wheat in summer-fallow was damaged in the Rosetown-Pennant area. Eggs were abundant on dead plants, but absent on heavily infested green growth. In Manitoba this aphid was found in the Eferson district on July 15, and by the end of the month it had spread over most of the southern part of the Province. The infestation, however, was restricted to subeconomic numbers by parasites. In Alberta the English grain aphid attracted some attention at harvest time, but caused little damage. In Saskatchewan, also, this species was present only in small numbers, although a light to moderate infestation occurred on fall-seeded rye in the Nipawin-Carrot River district. Wheat and oats were not attacked in the pre-ripening period as in 1952. In Manitoba, some fields of late oats in the Brandon district were severely infested. *Brachycolus tritici* Gill. was again abundant on intermediate and crested wheat grasses in experimental plots at Saskatoon, Sask., causing stunting and some mortality; and another aphid, *Rhopalosiphum padi* (L.), occurred in a medium infestation on oats at Nashwaaksis, N.B.

In Alberta, the sugar-beet root aphid was present in greater numbers than in the previous three years. Sugar beets were attacked wherever grown in the Province, but the most severe damage occurred in the western part of the Lethbridge Northern Irrigation District. Predators, including *Anthocoris musculus* (Say), *Thaumatomyia glabra* (Mg.), and several species of syrphids, reduced the aphid populations in many districts. The sugar-beet root aphid was also reported from southwestern Ontario, where it occurred in many sugar-beet areas but caused little damage. The pea aphid appeared in large numbers on alfalfa and in lesser numbers on clovers in southwestern Ontario, but was comparatively scarce on these crops in the Ottawa, Ont., area. The corn leaf aphid occurred commonly on corn in Ontario and Quebec, but damage was negligible. The clover aphid appeared in appreciable numbers in southwestern British Columbia but was held to subeconomic numbers by natural control factors.

**BARLEY JOINTWORM.**— *Harmolita hordei* (Harr.) was recorded from several grain fields in the Montreal, Que., area. It was again abundant in Prince Edward Island, where it occurred in almost every field of barley and mixed grain in Kings and Queens counties, particularly in the northern areas; infestation varied from 10 to 95 per cent and in some cases severe losses resulted when many stems broke down.

**CHINCH BUGS.**— An outbreak of *Blissus leucopterus* (Say) occurred in the western half of Essex County, Ont., in July. Sweet corn mainly was attacked and field corn to a lesser degree. The insects moved to the corn after the wheat had ripened. Prompt control measures prevented heavy losses. The chinch bug was found in most fields elsewhere in Essex County and the western part of Kent, but in limited numbers. In Newfoundland the hairy chinch bug, *Blissus hirtus* Montd., caused severe damage to many lawns.

**CLOVER CATERPILLARS.**— In northern Saskatchewan, small numbers of *Diacrisia* spp., observed on alfalfa, caused little damage, and in Manitoba *Colias* spp. were quite scarce. In Ontario, the clover head caterpillar, caused some severe damage to red clover in the Ottawa district, and adults were much more numerous than in 1951 or 1952.

**CLOVER SEED CHALCID.**— This insect, of minor importance in 1951 and 1952, damaged red clover and alfalfa rather seriously in the Ottawa, Ont., district.

**CLOVER SEED MIDGE.**— Although abundant on red clover in Carleton and Renfrew counties, Ont., this midge was less numerous and injurious than in 1951 or 1952.

**CLOVER WEEVILS.**— The sweetclover weevil caused considerable early damage to sweet clover in Alberta, but the crop recovered after abundant late-spring rains. In Saskatchewan, overwintered adults were more abundant and caused more damage to seedling sweet clover in the Saskatoon district than in any other year since 1949. The pest was again very abundant in the northeastern agricultural areas of Saskatchewan, but it has caused much less concern during the past two years, probably because an increasing proportion of sweet clover is being grown for soil improvement rather than for seed production. Overwintered adults were numerous also in southwestern Ontario, but their feeding did not seriously retard second-year stands of sweet clover. Larvae were scarce in mid-summer, apparently because of hot, dry weather, and very little damage was done to seedling stands. *Sitona lineata* (L.) was plentiful in pea and clover fields in the Fraser River delta area, B.C., and constituted a nuisance in threshed oats in one area. *Sitona tibialis* (Hbst.) occurred in small numbers in many alfalfa fields in northeastern Saskatchewan. In Ontario, *Hypera punctata* (F.) was observed on wild rice in Hastings County; in the Ottawa district, *Sitona hispidula* (F.) was locally numerous on alfalfa at Carp, and *Tychius stephensi* Schönh. was commonly observed on red clover, neither species causing any serious damage. In Newfoundland, *Hypera nigrirostris* (F.) was again numerous on red clover.

**CORN BORERS.**— In Saskatchewan, no survey for the European corn borer was conducted. However, a few larvae were taken in single gardens at Indian Head and Saskatoon. This was the first time that larvae were taken as far north as Saskatoon. The borer was very scarce in Manitoba and much less abundant than in recent years. Infestation was very spotty in southwestern Ontario. A few isolated fields in Essex, Kent, and Elgin counties were severely attacked but, in general, infestation was light to moderate. Stalk infestation was twice as high in Essex as in 1952; in Kent and Elgin counties stalk infestation was about the same as in 1952. The number of borers per stalk was almost double that for 1952 throughout the region. The second-generation population was very small as compared with the two previous years. There was some infestation in sweet peppers in the Chatham and Harrow districts, but it was of a minor nature. In Prince Edward County, some damage occurred in early sweet corn, but populations were greatly reduced from those of recent years. Injury to sweet corn in the Ottawa and Manotick areas was especially severe, even greater than in 1951 or 1952. A survey in Quebec revealed a generally reduced population and the following average percentage infestations: early sweet corn, 9.2; sweet corn, 3.7; late sweet corn, 3.1; and ensilage corn, 2.1. In the St. Jean, Que., area, ear infestation in sweet corn ranged from 10 to 25 per cent but in canning corn was less than 1 per cent, a marked reduction from 1952. Over-all infestation showed a slight reduction. In New Brunswick, the borer was present in all sweet corn areas surveyed and in slightly increased numbers in the Grand Lake region. Damage in Nova Scotia indicated that populations were generally maintained. *Helotropha reniformis* (Grt.) was not reported in Manitoba in 1953.

**CORN EARWORM.**— Though this species was of minor importance in Western Canada, local infestations in corn were reported from Keremeos and Creston, B.C., and Estevan, Sask.; and at Morden, Man., light damage was reported from a canning plant. In Eastern Canada the insect was of much greater importance. Infestation of late corn was generally severe in Ontario, particularly so in extreme southwestern areas, notably Essex County and, to a lesser degree, Kent County. Ear infestation ranged up to 100 per cent and in many cases the upper one-third of the ear was completely destroyed. Corn matured very early, lessening losses to some

extent. Tomatoes as well as corn were extensively attacked in the outbreak area, two to five per cent of almost all tomatoes entering the canning factories after September 21 being affected. Some factories were reported to have closed earlier than usual on this account. In New Brunswick, mid-season and late varieties of corn suffered 50 to 90 per cent damage. Infestation in Nova Scotia was the most severe since 1947, probably because of the mild winter of 1952-53; tomatoes as well as corn were extensively damaged in some areas. The insect was of little economic importance in Prince Edward Island and Newfoundland.

**FLAX BOLLWORM.**— Larvae of *Heliothis ononis* (Schiff.) were present in almost every flax field in the Rosetown-Elrose, Eston-Tyner, and Stranraer-Plenty districts of west-central Saskatchewan. Damage, however, averaged less than one per cent. The infestation was very light in comparison with that of 1944, but it was the largest and most uniform since 1948.

**FLEA BEETLES.**— *Phyllotreta* spp. caused little damage to sugar beets in Manitoba. The corn flea beetle, *Chaetocnema pulicaria* Melsh., was present in almost every corn field in Essex County and in most fields in Kent County, Ont. The beetle is a known carrier of Stewart's disease, which was present in many fields of early sweet corn in the district. Bacterial wilt affected field corn to a lesser degree. Adults of *Systena frontalis* (F.) were present in red clover from July to September at Ottawa, Ont., but damage was not serious.

**HESSIAN FLY.**— In British Columbia, light damage was caused by this pest in the Enderby-Armstrong district and at Glenmore near Kelowna. A local infestation causing some damage to wheat was reported from Swift Current, Sask. Barley was attacked near Rapid City, Man., and pupae were received from Neepawa. Not a single infested wheat plant was found in a late-season survey of southwestern Ontario, nor was any damage reported elsewhere in the Province.

**LEAFHOPPERS.**— By the end of August, leafhoppers were reported to be unusually common on all susceptible crops near Soda Creek, B.C. In Saskatchewan, the clover leafhopper and *Agalliopsis novella* (Say) again occurred in some alfalfa fields in the northeastern area of the Province, but no damage was observed. In southwestern Ontario, the potato leafhopper was extremely abundant. Hopperburn was evident in varying degrees in almost every alfalfa field visited in Kent, Essex, and Middlesex counties. In many cases the damage was very severe, resulting in greatly reduced hay yields. This was especially true of second and third cuttings. The insect was abundant also on alfalfa and red clover in eastern Ontario but damage was generally not severe. The six-spotted leafhopper was present in this area on clover and alfalfa in unusually small numbers.

**LEGUME-POLLINATING INSECTS.**— In Saskatchewan, *Bombus terricola* Kby. was the only important bumble bee pollinator of alfalfa in northeastern areas. Though it eventually appeared in about the same numbers as in 1952, brood development was about three weeks later in the season. *B. ternarius* Say, which in recent years had been of some importance as an alfalfa pollinator, was observed only occasionally in this crop. Occasional specimens of *B. borealis* Kby., *B. vagans* Sm., and *B. perplexus* Cress. were observed foraging alfalfa, and these species as well as *B. terricola* were common in a few red clover fields. *B. rufocinctus* Cress. was observed chiefly on hawk's-beard and sweet clover. Only occasional specimens of *B. californicus* Sm. were observed, but *Megachile* spp., present in the Nipawin-Torch River district in only very small numbers in 1952, were much more abundant in 1953. *M. melanophaea* Sm., one of the earlier species, appeared to be particularly abundant. At Wanless, Man., where special studies were made, the numbers of the common bumble bee species per unit area of alfalfa in one district were as follows:—

In June		In August
<i>Bombus terricola</i> Kby.	7	20
<i>B. ternarius</i> Say	8	1
<i>B. sylvicola</i> Kby.	15	rare
<i>B. rufocinctus</i> Cress.	10	rare
<i>B. vagans</i> Sm.	1	2
<i>B. fervidus</i> (F.)	Not observed	<i>B. borealis</i> Kby. rare



*B. rufocinctus* was the most abundant species on white Dutch clover, purple vetch, and fireweed, with *B. sylvicola* second. Bees of the genus *Anthophora* were very abundant at Wanless, nesting in decaying logs and in clay banks; they tripped a small percentage of alfalfa blossoms. *B. borealis*, *B. ternarius*, *B. rufocinctus*, and *B. terricola* were abundant at Altona and were important pollinators of sunflowers. In the Ottawa, Ont., district, *Andrena* spp. were very abundant in alfalfa and seed set was excellent. *Bombus* spp. were abundant in red clover, as in 1952, and here, too, seed set was very good.

**MAIZE BILLBUG.**— In Ontario, 30 acres of field corn in Southwold Township, Elgin County, on land that had been in sod for several years, suffered severe damage from *Calendra maidis* (Chitt.) when the plants were 8 to 12 inches high.

**PLANT BUGS.**— Populations of *Lygus* spp. remained small in Alberta alfalfa fields throughout the season, but in northern Saskatchewan species of this genus were again the major pests of alfalfa and caused severe damage in many seed fields. *Adelphocoris superbus* (Uhl.) was present in most alfalfa seed crops in Alberta, but was of minor economic importance. *A. lineolatus* (Goeze), recorded in economic numbers for the first time in Saskatchewan in the Hudson Bay district in 1952, occurred in somewhat larger numbers in the same area in 1953. Very small numbers were found in alfalfa in the Pas Trail, Nipawin, and White Fox districts. *A. rapidus* (Say) was again present in small numbers in Saskatchewan alfalfa fields. *Plagiognathus* sp., previously reported as *P. obscurus* Uhl. or the variety *fraternus* Uhl., occurred in numbers up to 20 per net sweep on alfalfa throughout northern Saskatchewan, and in northwestern areas was the predominant mirid in many fields. *Chlamydatus* sp. was found in small numbers in many alfalfa fields in northern areas of the Province but no damage was observed. In Manitoba, *Lygus lineolaris* (P. de B.) occurred on alfalfa in moderate numbers in the Turtle Mountain area and at Wanless. *A. lineolatus* and *A. rapidus* were present in numbers up to four per net sweep in the Turtle Mountain area, and in comparatively small numbers at Wanless. In the Ottawa Valley area in Ontario, *L. lineolaris* was numerous on alfalfa, red clover, and bird's-foot trefoil, populations being larger than in 1951 and smaller than in 1952. These crops were also attacked by *Plagiognathus chrysanthemi* (Wolff) in considerable numbers during the early part of the season; populations were larger than in 1951 or 1952. *A. lineolatus* was numerous in alfalfa during August but caused minor damage.

**SPITTLEBUGS.**— The meadow spittlebug occurred in outbreak numbers on strawberry on Vancouver Island, B.C., causing considerable crop reduction. In southwestern Ontario it appeared later in the season and was less abundant than in 1952. In eastern Ontario, numbers were comparable to those of 1952 and damage was negligible. At Ste. Anne de la Pocatiere, Que., populations in forage crops were smaller than in recent years.

**SUNFLOWER INSECTS.**— In Manitoba, only a few specimens of *Homoeosoma electellum* (Hulst) were observed. The moth *Phalonia hospes* Wlsh. continued to decline in numbers from its peak abundance in 1951, and damage dropped from a high of 6.5 per cent in 1951 to less than 2 per cent. Parasitism, largely responsible for the decline in population, increased from 65 per cent in 1952 to about 80 per cent. The chief species of parasites involved were *Chelonus* sp. near *shoshoneanorum* Vier. and *Glypta* sp., but *Macrocentrus ancylivorus* Roh., *Mastrus* sp., and *Horogenes* sp. were also present. Cutworm damage to sunflowers was very light, excepting one field in the Melita district where about 50 per cent thinning of the stand occurred. On one occasion, large numbers of cutworm moths were noted in sunflower bloom. Bumble bees were more prevalent on sunflower bloom than in previous years and appeared to be effective pollinators. The painted-lady, which occurred in outbreak numbers in 1949 and in moderate numbers in 1952, was not present, nor were any specimens of *Eucosma* sp. noted. The sunflower beetle, which occurred in near outbreak numbers in 1952, was present in moderate numbers. Predators, namely *Lebia atriventris* Say and chrysopid larvae, were more abundant than in 1952 and were observed feeding on larvae of the sunflower beetle. A mordellid, species undetermined, was more abundant on sunflowers at Altona and Brandon than in previous years. The sunflower maggot was present in reduced abundance, infestation being 54.7 per cent as compared with 69.7 per cent in 1952 and 96.4 per cent in 1951. *Oedicarena diffusa* Snow. continued to increase

in numbers since first observed in 1951. *Camptoprosopella borealis* Shew. was present in usual abundance. The ragweed plant bug was abundant, as in previous years. *Lygus* bugs were present in greater numbers than in recent years. Leafhoppers were generally very abundant on sunflowers as well as on other crops.

**THRIPS.**— Severe damage to barley, apparently by *Anaphothrips obscurus* (Mull), was reported early in July in the Peace River District, Alta. Several thousand acres were affected and damage ranged from 10 to 80 per cent of the heads. Early estimates placed the loss at 50 per cent in the affected areas, but later examination indicated that the actual loss might be far less. It was the first-formed heads only that suffered, and the reduced development in these apparently stimulated unusually heavy heads on the tiller shoots.

**TOBACCO INSECTS.**— The tobacco hornworm, *Phlegethontius sextus* (Johan.), which occurred in large numbers in extreme southwestern Ontario in 1952 for the first time on record in Canada, was again numerous, and the area of infestation increased to include the southern areas of Kent and Elgin and part of Norfolk county. The main infestation, in the Leamington-Kingsville area, was moderate to heavy on tobacco, ranging from 10 to 25 per cent of the plants; elsewhere it was comparatively light. Damage to tobacco by the tomato hornworm, *P. quinquemaculatus* (Haw.), was comparable to that of 1952. The infestation was most severe in the Leamington and Kingsville areas and was light in tobacco-growing areas east of Chatham, excepting a few heavily populated fields at Houghton, near Lake Erie. Cutworms of various species were very injurious to tobacco transplants in June, the amount of replanting necessary ranging from 5 to 75 per cent. The variation was, to some extent, a result of different control measures. Damage was most extensive in Norfolk and Kent counties. The green peach aphid appeared on tobacco somewhat later than usual and, as a result, did not develop damaging numbers in most fields. As in 1952, largest populations occurred near the shore of Lake Erie in Essex, Kent, and Elgin counties. Flea beetles, chiefly *Epitrix* spp., fed heavily on tobacco during June and July in Essex County.

**A VETCH BRUCHID.**— A bruchid, *Bruchus brachialis* Fahr., was found breeding on vetch at Grand Forks, B.C., on August 11. This was the first record of the species breeding in Canada. A native of Europe, it was first found in America in New Jersey in 1930.

**WHEAT STEM MAGGOT.**— This wheat pest was not reported in Saskatchewan, although in 1952 it was more abundant and widespread than for several years.

**WHEAT STEM SAWFLIES.**— In Alberta and Saskatchewan, populations of *Cephus cinctus* Nort. increased slightly over those of 1952: Noticeably heavier infestations occurred in the areas of Stirling-Foremost, Whitla, and Hilda-Schuler in Alberta, and in the Scott-Wilkie and Craik areas in Saskatchewan. Severe infestations occurred in the Regina plains, Weyburn-Radville, Outlook-Hanley-Kenaston, and Craik areas of Saskatchewan; and in the Hilda-Schuler, Whitla, Lethbridge-Foremost, and Nobleford-Vulcan areas of Alberta. Light to medium infestations occurred in the remainder of the prairie region. In Manitoba, infestation continued to be very light. In southwestern Ontario, *Cephus pygmaeus* (L.) was present in smaller numbers than in 1952 throughout wheatgrowing areas, and no serious damage was observed.

#### VEGETABLE INSECTS

**APHIDS.**— In southwestern British Columbia, aphids were generally more abundant than in 1952 on truck crops, especially on Vancouver Island. In the latter area, the bean aphid caused considerable loss in a large acreage of pole beans. Celery was extensively infested in areas about Cloverdale, Victoria, Armstrong, and Kelowna, B.C. The cabbage aphid was more abundant than usual on cabbage on Vancouver Island and was a pest of brussels sprouts and broccoli in the Abbotsford area. Light mid-season, and moderate to severe late-season infestations on cabbage, broccoli, brussels sprouts, and kohlrabi were reported from southwestern and eastern areas of Ontario, and from southern Quebec. Damage was negligible in Newfoundland. The turnip aphid was much less abundant than in 1952 in southwestern British Columbia. A moderate infestation of *Macrosiphum erigeronensis* (Thomas) rendered Chinese lettuce unmarketable in

Kent County, Ont. The melon aphid was present on melons and cucumbers in Essex County, and on Hubbard squash in Kent County, Ont., requiring control measures. The pea aphid was scarce in the eastern part of the lower Fraser Valley, B.C., but control measures were necessary in large acreages in the Ladner and Delta areas. In Manitoba, severe outbreaks occurred in the pea-growing area south of Winnipeg, in the St. Pierre, Altona, Morris, and St. Jean districts, and the area surrounding Portage la Prairie south and east to Elie and Newton Siding. This was the first reported outbreak of major importance in Manitoba. An increase in abundance on all leguminous crops was reported from Kent County, Ont., and early infestations on canning peas required control measures in many parts of the Province. Canning and field peas were lightly to moderately attacked in widely separated areas of southwestern Quebec, and this aphid along with another species of *Macrosiphum* was collected on bird's-foot trefoil at Ste. Anne de la Pocatiere, L'Assomption, and Sebastien. In Nova Scotia the pea aphid was more numerous than in 1952, especially in the Pictou district. Aphids, mainly *Macrosiphum solanifolii* (Ashm.), occurred on potato, in increased abundance in the Cariboo, B.C., district, were very scarce in Manitoba, and sufficiently numerous to warrant control measures in some Ontario districts, notably Essex County. *M. solanifolii* and *Myzus persicae* (Sulz.) occurred in outbreak numbers in many areas of Quebec. In New Brunswick, these species were present in average or above-average numbers, but *Aphis abbreviata* Patch was the predominant species throughout the season and was much more numerous than in 1952. *Aulacorthum solani* (Klth.) occurred in normal numbers. Aphid populations on potato in Kings County, N.S., were larger than for several years. In Prince Edward Island, *M. solanifolii* made up over 95 per cent of the population in infestations which were moderate to severe. In Newfoundland, *A. abbreviata* and *M. persicae* were widely but lightly distributed. *M. solanifolii* required control measures in a large planting of eggplant seedlings near Chatham, and on early tomatoes in Essex County, Ont. Control measures were also necessary on tomatoes at Osoyoos, B.C.

ASPARAGUS BEETLES.—*Crioceris asparagi* (L.), although slightly injurious to asparagus throughout the cutting season in Essex and Kent counties, Ont., was much less numerous than in 1952. Damage was reported also from Prince Edward County, Ont., and from Quebec. *C. duodecimpunctata* (L.) was very numerous at Winnipeg, Man., and numerous also in Ontario and Quebec, but caused negligible damage.

CABBAGEWORMS.—The imported cabbageworm occurred in normal numbers on Vancouver Island, B.C., but was much less abundant than in 1952 in the lower Fraser Valley. In Saskatchewan, damage was more severe than in 1952. From Battleford south to Cypress Hills and east to Moose Mountain, all cruciferous crops were 50 to 90 per cent defoliated, and in the area north of the Qu'Appelle River and east of the Saskatchewan River they were 10 to 20 per cent defoliated. This insect was less abundant than usual in Manitoba, but some severe damage occurred in gardens at Brandon. In Ontario, it was generally distributed in normal numbers in south-central and southwestern areas, but in the Ottawa district was less numerous than in any other year since records were begun in 1949. Damage was general and more or less normal throughout southern Quebec, and in the St. Lawrence Gulf province reports indicated generally reduced populations, notably in New Brunswick. The cabbage looper was very scarce in Manitoba, less numerous than in 1952 in southwestern Ontario, but slightly more numerous in the Ottawa district, and present in small numbers in New Brunswick. Its numbers were negligible compared with those of *Pieris rapae* (L.) and *Plutella maculipennis* (Curt.) at Ottawa. No damage of economic importance was reported from any province. The diamondback moth, too, was scarce in Manitoba, but in the Ottawa, Ont., area it occurred in light outbreak numbers, outnumbering any other cabbageworm species, and more numerous than in any year recorded. In the St. Lawrence Gulf provinces there were small to moderate numbers and little damage. *Evergestis pallidata* (Hufn.) [= *E. straminealis* (Hbn.)] caused slight injury to turnips in Prince Edward Island and severe injury to both cabbage and turnips in Newfoundland.

CARROT RUST FLY.—In British Columbia, second-generation larvae caused spotty but severe damage to carrots on Vancouver Island and comparatively light damage in the lower Fraser Valley. In the interior, severe damage was reported from Armstrong and Summerland, and a few flies were collected at Brocklehurst in the Thompson Valley. The insect had not



previously been reported from either Summerland or the Thompson Valley. No occurrences were reported from the Prairie Provinces. In Ontario, much severe first-generation damage was reported. At Bradford, second-generation larvae caused severe damage in some fields and very little in others. Celery growth was retarded in this area and to a lesser extent in the Burlington area. A few third-generation flies appeared at Bradford as a result of unusually warm fall weather. Very light damage was reported in eastern Ontario. In Quebec, damage to late carrots was commonly reported. In the St. Lawrence Gulf provinces, light infestations were reported from St. Andrews, Lincoln, and Shirley, N.B., and in large plantings at Waterville, N.S. Severe injury was reported from Truro, N.S., from Prince Edward Island, and from the Avalon Peninsula, Nfld.

**CELERY LEAF TIER.**— An unusual outbreak of this insect occurred in a field of celery at Kingsville, Ont., but most of the crop had already been harvested. A commercial crop of parsley at Jeannettes Creek, Ont., also was severely infested, causing some loss. An infestation in head lettuce had been reported in 1952.

**COLORADO POTATO BEETLE.**— Populations were large in the Kootenay, B.C., district, and the largest since 1949 in southern areas of Saskatchewan, but control measures kept losses to a minimum. In Manitoba, the insect was reported scarce at Winnipeg, moderately abundant at Brandon, and abundant at Melita. Throughout Ontario and Quebec, this beetle was present in somewhat increased numbers in many areas, but extensive damage occurred only in untreated fields. Locally reduced populations were reported from Chatham and Ottawa, Ont. Populations were large and very injurious to untreated crops in Nova Scotia and Prince Edward Island. In New Brunswick, numbers were small in June, but frequent rains hampered control measures and an extensive population build-up resulted.

**CORN EARWORM.**— This insect attacked tomatoes extensively in the Lake Erie and Lake Ontario districts, and canners claimed that they were sufficiently numerous to cause cessation of packing.

**CUCUMBER BEETLES.**— The striped cucumber beetle, rarely reported in Saskatchewan, occurred in considerable numbers in a three-acre field of cucumbers at Craven. In southwestern Ontario, it continued to be the most serious pest of cucumber, melons, and squash. Light infestations were reported from Prince Edward County and Ottawa, Ont., and in New Brunswick it was almost non-existent. The spotted cucumber beetle, which appears later in the season and is therefore less injurious, occurred commonly in southwestern Ontario but caused little damage.

**FLEA BEETLES.**— For the second successive year the potato flea beetle was not recorded in Saskatchewan, and in Manitoba populations were very small. In Ontario, it was somewhat more abundant than in 1952 in extreme southwestern areas, feeding heavily on potato, tomato, eggplant, and tobacco. In central and eastern areas of southern Ontario, damage generally was not severe, although some extensive feeding occurred on potatoes in Prince Edward County and the Ottawa Valley. Light to moderate damage to susceptible crops was reported from southern areas of Quebec and the St. Lawrence Gulf provinces, and some rather severe injury to potatoes in Prince Edward Island. The western potato flea beetle was again present in large numbers in the Soda Creek, B.C., area, causing extensive damage to tubers and vines. No specimens were taken in a survey north from Alexandria to Prince George and east to McBride. The tuber flea beetle, potentially a major threat to potatoes, was well controlled in southwestern areas of British Columbia and in the Thompson, Nicola, and Okanagan valleys. A second generation caused some damage at Chilliwack, and severe damage occurred in a few poorly treated fields in the interior. *Phyllotreta albionica* (Lec.) was scarce in southwestern British Columbia, but widespread and somewhat destructive in Newfoundland. *Phyllotreta* spp. were minor pests of radish in southern Saskatchewan, and of radish and turnip in Manitoba, notably at Brandon. *P. striolata* (F.) caused minor damage to garden crucifers from Manitoba eastward to Newfoundland. The hop flea beetle occurred in small numbers on potatoes in Prince Edward Island.

**LEAFHOPPERS.**— By mid August leafhoppers of various species were unusually common on grasses, legumes, and potatoes at Soda Creek, B.C. Damage to garden crops was at a low ebb for the third successive year in Saskatchewan. The potato leafhopper was not a serious pest in Manitoba, but in Ontario infestation was the most severe in recent years on all bean varieties and on potatoes in the Chatham area. Reports of damage to potatoes were received also from central and southeastern areas of southern Ontario. Infestations were light to moderate in the Ottawa Valley and in the Ste. Anne de la Pocatiere area of Quebec. Light infestations and no serious injury were reported from Prince Edward Island and Newfoundland. The six-spotted leafhopper occurred in Manitoba in normal numbers on potato, but in large numbers on carrot, causing considerable yellows, and in abundance on field peas in the Portage la Prairie area. In Ontario, light infestations caused minor to moderate damage to head lettuce in the Erieau and Holland marshes.

**MAGGOTS IN ONIONS.**— The onion maggot caused serious damage in untreated crops in the interior of British Columbia, but was believed to be less numerous than in recent years. Continued damage was reported in Alberta, but less damage generally than in 1952 in this province and in Saskatchewan. In the latter province damage was negligible south of an east-west line from Cypress Hills to Moose Mountain. North of a line from North Battleford to Yorktown, 60 to 100 per cent mortality of onions was common; and in the market garden areas of the Province, 60 to 80 per cent of onions were killed as in 1952. Infestations were relatively low at Brandon and Winnipeg, Man., probably a result of heavy rains, but some severe damage was reported from Melita. Infestations were generally lighter than in 1952 in most areas of Ontario, although commercial crops were damaged in the Erieau Marsh, Jeannettes Creek, and Holland Marsh areas. In Quebec, 25 to 75 per cent of onion seedlings in muck-land areas near Montreal were destroyed, and in sandy loam soils in the St. Cesaire district 20 to 30 per cent of the plants were killed. The insect was exceedingly destructive also in the Ste. Anne de la Pocatiere district. Infestation in general was comparable to that of recent years. Reports of damage in the St. Lawrence Gulf provinces were confined mainly to small gardens. Larvae of *Paragopsis strigatus* (Fall.) were taken in fall onions at Kelowna, B.C., and were reported from Ste. Anne de la Pocatiere, Que.; the economic status of this species is not known.

**MEXICAN BEAN BEETLE.**— For the third consecutive year this pest caused economic losses in southwestern Ontario. The area of infestation increased, and in Essex County the insect was the most serious pest of beans in home gardens during July and August. In Quebec, a few foci of infestation persisted in the Rougemont and St. Antoine Abbé districts.

**MITES.**— Reports of damage to tomato plants by the tomato russet mite were not as numerous as in 1952 in Essex County, Ont.

**ONION THRIPS.**— Onions were severely damaged in untreated fields in the Okanagan and Grand Forks districts of British Columbia. In southwestern Ontario, infestations and damage were generally more severe than in 1952, and severe infestations were general throughout the central and western agricultural areas of southern Ontario.

**PEA MOTH.**— No damage was reported in southwestern British Columbia, and in Prince Edward Island infestation was about normal.

**PLANT BUGS.**— At Grand Forks, B.C., *Lygus scutellatus* Uhl. was somewhat more abundant in carrot seed crops than in 1952, but infestations remained very low compared with outbreaks in 1947 and 1948. Very few bugs were noted on dill seed plants during the season. Light to moderate infestations were found on stands of a wild umbelliferous host, *Sium sauve* Walt., during late summer at Kamloops, Falkland, and Peachland. Populations of *L. lineolaris* (P. de B.) and *L. elisus* Van D. in carrot seed crops were small throughout the season. The four-lined plant bug was moderately common in vegetable gardens in Hastings County, Ont.

**POTATO STEM BORER.**— Young corn plants were commonly attacked by this borer in gardens from Ste. Anne de la Pocatiere to Rimouski, Que. Rhubarb was damaged in St. John County, N.B., and occasional specimens were found on potato in Newfoundland.

**ROOT MAGGOTS IN CRUCIFERS.**— Root maggots, chiefly the cabbage maggot, were present in usual numbers on stem crucifers in southwestern British Columbia, control measures being necessary to prevent crop failures. Populations showed a substantial increase over the previous three years in the Courtenay area, probably a result of favourable soil moisture conditions. In the lower Fraser Valley, late damage was done to broccoli and brussels sprouts, and in the Kelowna area turnips were again severely damaged. In northern Alberta, reports of damage were more numerous than usual. At Cranford some turnip crops were completely ruined and damage was reported also from Iron Springs and Lethbridge. Crucifers in a garden at Regina Beach were moderately infested with the cabbage maggot, the first definite record in the Province. In Ontario, moderate to severe early-season damage to crucifers was reported from Essex, Hastings, and Prince Edward counties and from the Burlington area. An unusual late-season infestation developed on radish at Jeannettes Creek. Infestation in the Holland Marsh was below that of 1952, and in the Ottawa area about average. The insect continued to be the major pest of early crucifers in Quebec. It caused only slight losses in New Brunswick, infestation being the lightest in seven years in the Maugerville-Sheffield area. Damage to early cabbage and to turnips was more severe than in 1952 in Nova Scotia. Injury to early cabbage was comparatively light in Prince Edward Island and Newfoundland, but turnips were more severely damaged than in 1952 in both provinces. *Hylemya planipalpis* (Stein.) and *H. floralis* (Fall.) [= *H. crucifera* Huck.] caused somewhat less damage to early radish than in 1952 in Saskatchewan and Manitoba, and generally less damage to turnips in the latter province. *H. floralis* was, as usual, restricted mainly to the black soils zone in Saskatchewan, damaging from 40 to 100 per cent of all cultivated crucifers. South of this zone damage was negligible, except in irrigated areas.

**SEED-CORN MAGGOT.**— In British Columbia, beans were severely damaged near Lillooet, and for the first time in many years at Chilliwack. Eggs and adults were collected at Lethbridge, Alta., but no larvae were found. Infestation in southwestern Ontario was the most severe on record, all varieties of beans, including the soybean crop, being severely attacked. The latter crop has in the past been comparatively free of insect depredations. In Elgin County seed pieces of late potatoes were severely infested. In Quebec, injury to beans was light near Quebec City and severe in the Ste. Anne de la Pocatiere area. Peas and beans suffered severe losses around Fredricton, N.B., and squash was attacked in the Sussex area. In Nova Scotia, beans had to be reseeded in many fields and cucumbers were commonly damaged. Cucumbers were severely damaged also in Prince Edward Island, but other crops were not seriously injured.

**SLUGS.**— Slugs persisted in above-average numbers in the Okanagan, B.C., area for the third successive year. Favourable weather conditions in the Prairie Provinces resulted in large populations and some severe damage, notably in northern Alberta and Manitoba. Little damage was reported from Ontario and Quebec, and numbers were reduced in most areas of the St. Lawrence Gulf provinces. However, some severe damage was reported from Halifax County, N.S., and Cape Breton Island.

**SPINACH LEAF MINER.**— Damage to spinach and beets was less than in 1952 at Regina, Sask., negligible in Manitoba, and about average, but much less than in 1951, in southwestern Ontario.

**SPRINGTAILS.**—Populations were large but injury light at Ste. Anne de la Pocatiere, Que. Spring damage to vegetables was above average at Truro, N.S., and Newfoundland reported little damage.

**SQUASH BUG.**— In Ontario, insolated colonies were present in southwestern districts, but damage was minor. Reports of injury were numerous in the Guelph area, and a severe outbreak caused major damage to pumpkin and squash in Prince Edward County and the district between Belleville and Deseronto.

**SQUASH VINE BORER.**— In southwestern Ontario, infestations in commercial acreages of Golden Hubbard squash and Boston marrow were less severe than in 1952. In small market and kitchen gardens infestations were severe. There were indications that the pest is becoming more widespread in this area.



**TOMATO HORNWORM.**—Only a few infestations were reported in Ontario, and although slightly more numerous than in 1952 in Quebec, the insect was of minor importance for the third consecutive year. A single infestation was reported from Greenwich, N.S.

**MISCELLANEOUS.**—The cabbage seedpod weevil occurred on radish at Armstrong, B.C. Adults of the peppergrass beetle defoliated turnips by cutting the leaf petioles, then ate the crowns to the ground at Treesbank, Man. Small numbers of the potato psyllid were reported in the lower St. Lawrence Valley. Large numbers of a weevil, *Trachyphloeus bifoviolatus* (Beck.), severely damaged cucumbers and beans in an area of Prince Edward Island. Sugar beets were damaged by the zebra caterpillar at St. Hyacinthe, Que.

#### FRUIT INSECTS

**APHIDS.** *Aphis pomi* Deg. was of little importance in British Columbia. In Ontario it was more abundant than usual in all apple-growing areas, and Quebec reported severe infestations in several orchards in southwestern areas of the Province. New Brunswick and Nova Scotia reported small to moderate numbers of minor economic importance. *Anuraphis roseus* Baker occurred in small numbers in Ontario, except in a few orchards in eastern counties and in the Georgian Bay area. In Quebec, too, only a few orchards were reported infested. In Nova Scotia, however, the species was more plentiful than usual and control materials were applied in some areas, but damage was not serious. *Eriosoma lanigerum* (Hausm.) was a much less serious pest than in 1952 in the Okanagan and Kootenay, B.C., valleys, largely because of heavy parasitism by *Aphelinus mali* (Hald.). Although still causing little injury in Ontario, populations were reported to be increasing, and general increases were reported also from Quebec. Only small numbers were observed in Nova Scotia. *Rhopalosiphum prunifoliae* (Fitch) was moderately abundant early in the season in Nova Scotia. The black cherry aphid was of minor importance in both British Columbia and Ontario. The currant aphid caused light damage to red currants at Kerrobert, Sask., and developed in large numbers in some black currant plantations in Nova Scotia. Reports from Manitoba indicated no damage. The green peach aphid was a serious pest, occasioning some losses to fruit growers in parts of British Columbia, particularly in southern areas. Small numbers appeared on potatoes and moderate numbers on turnips in Prince Edward Island. For the second successive year, heavy infestations of the black peach aphid developed on young peach trees in Essex County, Ont. In British Columbia, the mealy plum aphid was a minor problem, although some growers reported increases. In Ontario it was very abundant in Essex County, but of minor importance in the Niagara Peninsula. *Capitophorus minor* (Forbes) and *C. fragaefolii* (Ckll.) were common in most strawberry plantations in the Washademoak and Belleisle areas in New Brunswick. Another species, *Myzus porosus* Sand., was less common.

**APPLE MEALYBUG.**—This insect has been satisfactorily controlled by the parasite *Allotropa utilis* Mues. in British Columbia in recent years. Light infestations occurred in New Brunswick and Nova Scotia.

**APPLE SEED CHALCID.**—Infestations of this insect were heavy in unsprayed orchards at Morden, Man.

**APPLE (AND BLUEBERRY) MAGGOT.**—Reports from Manitoba indicate that this insect is present throughout the southern part of the Province. General abundance was reported in Ontario apple orchards, with increases indicated in eastern counties and in the Toronto-Hamilton area. A severe general outbreak occurred in the St. Jean, Que., area. No orchard survey was carried out in New Brunswick. Some increase in the number of commercial orchards infested was reported from Nova Scotia, and in Prince Edward Island damage was, as usual, extensive in non-commercial orchards. The insect was again prevalent on blueberry in large areas of New Brunswick, and more injurious than in 1952 in Prince Edward Island. This crop was free of infestation in Newfoundland.

**BLUEBERRY CUTWORMS.**—Blueberry cutworms were collected in approximately the same numbers and densities as in 1952 in New Brunswick, except *Actebia fennica* (Tausch.), which apparently increased during the past two seasons. In fall sweepings *Syngnatha epigaea*

(Grt.) was the most prevalent species. Other lepidopterous larvae collected included *Polia purpurissata* (Grt.), *Spaelotis clandestina* (Harr.), *Rhynchagrotis cupida* (Grt.), *Euxoa declarata decolor* (Morr.), *Graphiphora smithi* (Snell.), *G. collaris* (G. & R.), and *Eucirrhoedia pampina* (Gn.).

**BLUEBERRY SAWFLIES.**— The sawfly *Neopareophora litura* (Klug) was found in all parts of New Brunswick during a survey. Generally this insect is not found in the Province in infestations heavy enough to cause concern, *Pristiphora idiota* (Nort.) and *P. bivittata* (Nort.) were collected in Charlotte County, N.B., but were not common.

**CASEBEARERS.**— The cigar casebearer and the pistol casebearer were very scarce in Norfolk and Essex counties, Ont., and in the Niagara apple district. Scattered occurrences of the cigar casebearer and light infestations of the cherry casebearer were reported from St. Jean, Que.

**CHERRY FRUIT FLIES.**— *Rhagoletis fausta* (O.S.) caused some damage to cherries in the Kootenay Lake, B.C., area, where it was not adequately controlled; and an infestation on pin cherry was reported from Morden, Man. *Rhagoletis cingulata* (Loew) caused serious fruit damage in some areas of Prince Edward Island, notably near urban centres. Both species were well controlled in commercial orchards in Ontario.

**CHERRY FRUITWORM.**— This cherry pest was well controlled in its limited area of distribution in East Kelowna, B.C. Only one infested orchard was reported in Ontario.

**CODLING MOTH.**— Little injury occurred in the Okanagan and Kootenay valleys, B.C., except where second-brood larvae were inadequately controlled. Weather conditions favourable to the insect in Ontario resulted in somewhat greater fruit injury than in 1952 in Essex County, but elsewhere in the Province good control was obtained. An increase in both fruit injury and the area affected in southwestern Quebec was reported from St. Jean. At Rougemont, Que., fruit injury amounted to 10 to 15 per cent in several apple orchards. Populations were reported to be still at a low level in the area about Quebec City and in the lower St. Lawrence Valley. Moderate damage occurred in a few large orchards in the Gagetown area of New Brunswick, and at Springhill and Keswick there was a sudden increase in populations. Damage to apples, although less than in 1952, was general throughout the Annapolis Valley, N.S.; the crop was smaller than in 1952 and more spraying was done than in recent years.

**CRANBERRY FRUITWORM.**— This insect was again abundant and difficult to control on cranberry plantings in New Brunswick.

**CURCULIONIDS.**— The apple curculio caused appreciable damage in a few orchards in southwestern Quebec. Light infestations of the plum curculio were reported from Morden, Winnipeg, and St. James, Man. In Norfolk County and the Niagara and Toronto-Hamilton districts, Ont., a prolonged period of cool, wet weather soon after petal-fall resulted in less effective control than usual. In general, injury was very light on apple, but more abundant than in 1952 on plum, peach, and apricot. It was considerably less abundant than usual in commercial orchards in Essex County. The insect continued, as in recent years, to be a major pest, particularly in neglected orchards, throughout southern Quebec. *Magdalis gracilis* Lec. damaged the foliage of plum in the Arrow Park, B.C., district. The strawberry weevil caused severe losses in some strawberry plantings at Portage la Prairie, Man., and was also reported from Winnipeg. Although the insect was generally scarce in the Niagara and Toronto-Hamilton districts in Ontario, some injury occurred in a few plantings, and in Essex County adults were extremely abundant. Light to moderate injury to strawberries was reported from southern Quebec. In New Brunswick, the insect was of little importance, even in areas where it had been a major pest a few years ago. Reduced numbers and damage were reported also from Nova Scotia and Prince Edward Island. The root weevils *Brachyrhinus ovatus* (L.) and *B. sulcatus* (F.) continued to be the most important economic pests of strawberries in both the Vancouver Island and lower Fraser Valley areas of British Columbia. The latter species was particularly injurious in plantings where sawdust was used as a mulch and where sprinkler irrigation was practised. It was reported as injurious also at Wyndell, B.C., in the interior of the Province.

Some damage to strawberries occurred in Nova Scotia, especially in Yarmouth County. *B. ovatus* damaged strawberries in the Kamloops, Okanagan, and Kootenay, B.C., districts, and killed peonies in East Kelowna. It was commonly reported in Manitoba, a severe infestation occurring at Morden.

**CURRENT BORER.**— This insect was again reported in light infestation at Morden, Man.

**CURRENT FRUIT FLY.**— Infestations in northern Alberta were greatly reduced in many plantings by the use of insecticides. Normal abundance was recorded in north and northeast Saskatchewan and damage was reported from Regina, Redvers, and Harris. In Manitoba, damage was reported from Winnipeg, St. Vital, Plumas, Portage la Prairie, and Brandon, the insect being satisfactorily controlled at Morden. Previous reports of this insect in Ontario were from east and north of Toronto; in 1953 it was found west of Toronto at Clarkson in Peel County.

**EYE-SPOTTED BUD MOTH.**— Populations of this species were larger than in 1952 and injurious to late apple varieties in the Okanagan and Kootenay valleys, B.C. Considerable injury occurred in eastern Ontario orchards, but elsewhere in the Province damage was light. Severe damage in neglected orchards was reported from St. Hilaire, Rougemont, and Abbotsford, Que., and the insect was generally injurious elsewhere in the Province, where not controlled. Somewhat reduced infestations were reported from the Springhill and Keswick areas of New Brunswick, the insect being generally a much less serious pest than it was a few years ago. A general decline in numbers was reported also from Nova Scotia, although some orchards were severely infested, particularly where DDT had been used for some time. In Prince Edward Island, infestation was reported to be heavier than in 1952 and damage severe in some orchards.

**FRUIT TREE BORERS.**— The peach tree borer appeared to be more numerous than in 1952, especially in young orchards, in the Okanagan and Kootenay valleys, B.C., and increased in numbers also in the Niagara, Ont., area, especially on peach nursery stock. The lesser peach tree borer persisted in injurious numbers in Essex County, Ont., and in British Columbia the peach twig borer was again of little importance. The roundheaded apple tree borer occurred commonly in young orchards at St. Jean, Que., and was less numerous than in 1952 in New Brunswick.

**GRAPE BERRY MOTH.**— This insect increased in abundance in both the Niagara area and in Essex County, Ont. In the former area it caused considerably more damage than for several years.

**GREEN FRUITWORMS.**— *Graptolitha* spp. caused considerable injury to pear in Norfolk County, Ont., and to apple in several eastern Ontario counties, where control was inadequate. Smaller populations than in 1951 and 1952 caused only moderate, scattered damage in southwestern Quebec. A reduction in injury to apples was reported also from Nova Scotia. A light infestation of the lesser appleworm occurred at Morden, Man., and in this area populations of the fall cankerworm were very small compared with the severe outbreak of 1952. Both the latter species and the spring cankerworm were more prevalent than usual in eastern Ontario and in Norfolk County, causing moderate injury to poorly sprayed fruit trees and to nursery stock. In some areas of the Province all broad-leaved trees were severely defoliated in June. The spring cankerworm was more prevalent than in 1952 at St. Jean, Que., and the fall cankerworm was observed in many orchards in Kings County, N.S., some of which required control measures. A decline in numbers occurred in Hants County, N. S.

**IMPORTED CURRENTWORM.**— Many currant bushes were attacked in widely scattered areas of northern Alberta. In Saskatchewan, a single infestation was reported from Kelliher. Light infestations were observed at Brandon and Dauphin, Man. The insect was more general than in recent years in Nova Scotia, caused complete defoliation of gooseberries in some areas of Prince Edward Island, and was less numerous than in 1952 in Newfoundland, occurring only in a few minor infestations.



**LEAFHOPPERS.**— The bramble leafhopper, *Typhlocyba tenerrima* H.-S., was very numerous and caused extensive damage to loganberries on Vancouver Island, especially to the newly developing canes. The winter of 1952-53 was the first in which large numbers of adults were observed to overwinter. *Macropsis fuscula* (Zett.), not recorded in North America until July, 1952, continued to spread and cause damage to loganberry plantings on Lulu Island, B.C. It caused an accumulation of considerable quantities of a secretion like honey dew on the fruit and foliage. Raspberries growing nearby were not affected. The buffalo treehopper continued to cause considerable damage to young apple trees at Vernon, B.C., and in the St. Jean, Que., area. The white apple leafhopper was troublesome in apple orchards in southwestern Quebec, and in Nova Scotia populations remained at a comparatively low level.

**LEAF MINERS.**— An unidentified leaf miner was fairly abundant in several apple orchards at Chateauguay and Farnham, Que., and *Lithocolletis malimalifoliella* Braun occurred in moderate numbers in some orchards in Nova Scotia.

**LEAF ROLLERS.**— The fruit tree leaf roller, a fairly serious orchard pest in the Okanagan and Kootenay, B.C., valleys, persisted in its usual numbers. In Ontario and Quebec it was of little economic importance in commercial orchards. The redbanded leaf roller was generally distributed in apple orchards in Ontario and Quebec. It was more numerous than in 1952 in Ontario, but caused serious injury in only a few orchards. In southwestern Quebec it was considered a major pest. In Nova Scotia one or more of the various leaf rollers occurred in most apple orchards, but usually in comparatively small numbers. The gray-banded leaf roller may have increased slightly. The oblique-banded leaf roller, a white-triangle leaf roller, *Archips persicana* (Fitch), and a three-lined leaf roller, *Pandemis limitata* (Rob.) were present in about the same numbers as in 1952. In most orchards the green budworm declined in numbers and was of little importance. Severe infestations of the oblique-banded leaf roller occurred on filberts in southwestern British Columbia. There were more heavy strawberry leaf roller infestations than usual in Norfolk County, Ont., and small numbers of *Archips obsoletana* Wlkr. were also found. The common species was somewhat more prevalent than usual in the Toronto-Hamilton area, but was not unusually troublesome in the Niagara Peninsula. This species was reported to be a minor pest in Newfoundland. Another leaf roller, *Exartema olivaceanum* (Fern.), was more numerous on strawberry than in previous years in the Vancouver Island, B.C., area. As many as 25 per cent of the leaves per plant were damaged in some plantings. The orange tortrix caused damage to loganberries and raspberries in the Oak Bay area, Vancouver Island; this was the first time this insect had been observed causing economic damage to brambles in Canada. It has occurred in British Columbia as a greenhouse pest since 1930. During 1952 it was found causing damage to peaches in the Oak Bay area for the first time. In Washington and Oregon, U.S.A., it has been a major pest of brambles for several years.

**MITES.**— The European red mite was probably the most troublesome mite in the Okanagan Valley, B.C. In certain orchards of some areas, including Oliver, Penticton, Summerland, and Kelowna districts, there was evidence of strains resistant to organic phosphate insecticides. Infestation in Ontario orchards was very uneven. Moderate to heavy infestations were reported on apple in eastern Ontario. In the Niagara Peninsula, Norfolk County, and Essex County, early infestations were generally fairly light, with a considerable build-up in August and September. Infestation on peach and plum in the Niagara area was generally lighter than usual. In Quebec, this mite was a major pest in all apple-growing districts. Populations were larger than in 1952 in the St. Jean area, especially where certain sulphur fungicides had been used, and were reported to be smaller than in 1952 in the St. Anne de la Pocatiere area. In Nova Scotia the mite was comparatively scarce, except for some heavy infestations in a few orchards where DDT had been used. Normal populations caused some damage to apple foliage in Prince Edward Island. An outbreak of the two-spotted spider mite occurred on strawberries grown on virgin land in the Keating district, Vancouver Island, B.C. This was the first known case in which control measures were necessary for this species before the picking season. The mite was of little concern in the Okanagan and Kootenay valleys, although there was an increase in numbers toward the end of the season. Strawberries were again infested in the Magna Bay, B.C., area. Raspberries were severely attacked in northern Alberta. A reduction in numbers, which began

in 1951, continued in Saskatchewan. The two-spotted spider mite was again generally distributed in peach and apple orchards in Ontario, but in only a very few cases was there any appreciable injury. In eastern Ontario there were heavy infestations in several apple orchards in August, and some defoliation resulted. A few apple orchards in the Toronto-Hamilton area were also heavily infested in late August by this species or the four-spotted spider mite. The species was of minor importance on apple at St. Jean, Que., and in Nova Scotia it was not observed on apple and was scarce on other plants. The clover mite was of little importance in Western Canada. In the east it was noted in small numbers in many apple, pear, and sour cherry orchards in Ontario, and was general on apple in Nova Scotia, but little economic damage resulted. The pear leaf blister mite appeared to increase in some Okanagan and Kootenay, B.C., orchards. An increase was indicated also in Prince Edward Island, where slight to moderate injury occurred on pear trees. The Pacific mite was of little importance in British Columbia, and although it and *Eotetranychus mcDanieli* (McG.) occurred in very large numbers during the spring at Morden, Man., adverse weather conditions soon reduced populations to subeconomic levels. Populations of a predacious mite, *Typhlodromus* sp., were reported to be small in this area, and at Grahamdale, Man., plum was infested by gall mites. In the Okanagan and Kootenay, B.C., areas, rust mites, *Phyllocoptes* spp., caused more trouble than in 1952, especially on cherry and apple, and in some orchards were the most serious pests of the season. In these areas, too, a yellow spider mite, *Eotetranychus carpini borealis* (Ewing), caused damage during the latter part of the season, as in 1952.

**NITIDULIDS.**— Nitidulids continued to be troublesome on raspberry in southwestern Ontario, but injury to corn was the lightest in many years.

**ORIENTAL FRUIT MOTH.**— Infestation of peaches in Essex, Kent, and Lambton counties, Ont., was slightly greater than in 1952, but losses were minor except where control measures were inadequate. In the Niagara Peninsula the infestation was again at a generally low level and late injury on mid-season varieties was somewhat less than in 1952. However, a few orchards were moderately to heavily infested.

**PEAR PSYLLA.**— Although widespread in the Okanagan and Kootenay, B.C., valleys, pear psylla was easily controlled and not troublesome. It was found at Renata, B.C., for the first time in the district. In the Niagara Peninsula, Ont., the insect has been increasingly difficult to control and was abundant in many orchards. It was not a serious pest in Essex County, Ont., and occurred only in moderate numbers in Nova Scotia.

**PEAR-SLUG.**— Severe infestations of the pear slug occurred on young fruit trees in the Westbank and Oliver, B.C., areas, and on plum, cherry, and cotoneaster throughout Edmonton, Alta. Two infestations on plum were reported from Winnipeg, Man., and in Ontario the insect was of little importance on pear and cherry. At Ste. Anne de la Pocatiere, Que., an unusual outbreak occurred on cherry and plum during the latter part of September. In Prince Edward Island infestation of cherry was common in neglected orchards, and damage in certain areas more severe than usual. Conditions in Newfoundland were comparable to those of 1952. Larvae of the sawfly *Pristiphora californica* (Marl.) were reported to be increasing in numbers in the southern Okanagan Valley, B.C.

**PLANT BUGS.**— *Lygus* spp. were generally unimportant in British Columbia, but increased damage to fruit was reported in the Oliver area. Strawberry beds were damaged at Morden, Man. In Ontario, catfacing injury was not serious in the peach-growing areas, but appreciable injury was done to apples in the eastern part of the Province. Some damage was reported also from the Rougemont and Frelighsburg districts of Quebec. In Nova Scotia, *Neolygus communis novascotiensis* Kgt. continued to be scarce and *Campylomma verbasci* (Meyer) caused minor damage to fruit in some orchards.

**RASPBERRY CANE BORERS.**— Injury by *Oberia affinis* Leng was very conspicuous in the form of killed and "ringed" canes in patches of wild red raspberry and wild blackberry throughout eastern Ontario. Little change in populations of the raspberry cane borer occurred in Quebec, but in New Brunswick damage was the lightest in several years.

**RASPBERRY FRUITWORMS.**— Damage by *Byturus* sp. was light in the southern quarter of Saskatchewan, and the lightest in several years at Saskatoon, Sask. A severe infestation was reported from Indian Head, Sask.

**RASPBERRY ROOT BORER.**— This cane fruit pest continued to increase in raspberry and loganberry plantings in the coastal areas of British Columbia.

**RASPBERRY SAWFLY.**— This sawfly was of little importance in the Prairie Provinces, the only recorded damage being at Maple Creek, Sask., and Morden, Man. Damage was common but not serious throughout Nova Scotia.

**ROSE CHAFERS.**— The rose chafer was commonly reported on ornamentals, raspberry, grape, and other hosts in southwestern Ontario, but damage was not severe. Large numbers occurred also in some apple orchards in sandy soil areas at Franklin, Abbotsford, and Sabrevois, Que. The green rose chafer was present in large numbers on raspberry in the Smithers, B.C., district, but caused no damage.

**SCALE INSECTS.**— Oystershell scale was reported at a very low ebb in British Columbia, and of little importance in commercial orchards in Ontario. In New Brunswick it was reported to be a serious pest in a few orchards near Woodstock, but was well controlled in the lower St. John Valley. Populations remained at a low level in Nova Scotia. European fruit lecanium was more abundant than usual on Spy apple along the north shore of Lake Ontario, and numerous in several plum and peach orchards in the Toronto-Hamilton area. Although usually rare on apple in the Annapolis Valley, N.S., it was present in sufficient numbers in one orchard to discolour the fruit and occurred in large numbers in several other orchards, all of which had been sprayed with DDT for at least two years. San Jose scale was a fairly serious pest in the Keremeos-Cawston, B.C., area, and of little importance in most commercial orchards in Ontario. Cottony peach scale was somewhat less prevalent than in 1952 in the Niagara Peninsula, Ont. *Lecanium* sp. was reported to be little changed in status in the Okanagan and Similkameen, B.C., valleys, but increased in abundance in the Creston, B.C., area. *Pulvinaria* sp. appeared to be generally reduced in numbers, and the European fruit scale less common than in 1952, in British Columbia. A light infestation of scurfy scale occurred at Morden, Man.

**A STRAWBERRY CHLAMISUS.**— *Chlamisus fragariae* Brown, reported as a major pest of strawberry in the Belleisle, N.B., area in 1951, was found only in trace numbers.

**STRAWBERRY CROWN MINER.**— Severe leaf damage to strawberry in the Virden, Man., area was believed to have been caused by this insect. In Ontario, it caused light to moderate damage in a large plantation at Brantford, and was believed to have originated on plants from British Columbia.

**TENT CATERPILLARS AND WEBWORMS.**— Fruit trees in the Chilliwack, B.C., district were fairly heavily infested by the western tent caterpillar. In Saskatchewan, *Malacosoma* spp. were less numerous than in 1952 and no damage was reported. *Malacosoma americanum* (F.) and *M. distria* Hbn. were abundant in Hastings County, and the most severe outbreak in many years occurred in Prince Edward County, Ont. In the St. Jean, Que., area, many unsprayed orchard and other deciduous trees were completely defoliated. Populations were much smaller than in 1952 in New Brunswick, but still large in Nova Scotia. In the latter Province *M. distria* decreased considerably in Kings County, but control measures were still necessary in many orchards in both Kings and Hants counties. *Hyphantria textor* Harr. continued to be very scarce in the Province. In Ontario, the ugly-nest caterpillar was very abundant on choke cherry in Norfolk County, and at St. Jean, Que., it was plentiful along roadsides.

**THRIPS.**— In the Okanagan and Kootenay, B.C., valleys, thrips caused less "pansy spot" on MacIntosh and Spartan apples than in 1952. Thrips damage on raspberry was reported from St. Jean, Que., and in New Brunswick *Frankliniella vaccinii* Morgan occurred commonly on blueberry, but no heavy infestations were reported.



**WHITE GRUBS.**— A report of damage to strawberry was received from Kamsack, Sask. In the Niagara Peninsula, Ont., and the Grand Lake and Washademoak, N.B., areas, damage to this crop was very light. Nursery stock, too, was only lightly damaged in the Niagara Peninsula.

**WINTER MOTH.**— This recently introduced pest, *Operophtera brumata* (L.), was sufficiently numerous on the south shore of Nova Scotia to defoliate unsprayed apple trees.

**YELLOW-NECKED CATERPILLAR.**— An apple orchard in Westmorland County, N.B., was practically defoliated by an outbreak of this insect.

**PREDATORS OF ORCHARDS PESTS.**— In Nova Scotia, predacious mirids, thrips, and mites were about as numerous as in 1952. *Haplothrips faurei* Hood was commonly found and was somewhat more abundant than in 1952; the other predacious thrips, *Leptothrips mali* (Fitch), although not nearly as numerous, was also general in distribution. The most commonly occurring mirids and anthocorids were *Hyaliodes harti* Knight and *Anthocoris musculus* (Say). *H. harti* was again abundant in a great many orchards. The occurrence of *A. musculus* remained about the same as in 1952. Predacious mites, *Typhlodromus* spp., which prey on the European red mite and other mites, continued to be general in distribution and occurred in about the same numbers as in 1952. *Anystis agilis* Banks, another predacious mite, formerly found only in unsprayed apple trees, has been appearing in many commercial orchards since the adoption of less harmful spray schedules. Coccinellids were present in about average numbers and were important in keeping apple aphids under control. Aphid-lions (Chrysopidae) and syrphid flies also occurred in about average numbers.

#### INSECTS AFFECTING GREENHOUSE AND ORNAMENTAL PLANTS

**APHIDS.**— Reports of aphid damage were scarce in Saskatchewan, but begonias were injured at Grenfell, and delphinium in a few gardens at Saskatoon. In Manitoba, aphids were unusually abundant on ornamentals. The melon aphid was injurious to cucumber in several greenhouses in the Leamington, Ont., area during March and April. In the Edmunston, N.B., area, *Myzus circumflexus* (Buck.) was injurious to house plants.

**BLACK VINE WEEVIL.**— This weevil damaged begonias in a greenhouse at Winnipeg, Man.; and at Ottawa, Ont., foundation plantings of *Taxus* sp. were again infested, and adults damaged English ivy in a dwelling.

**CHRYSOMELID ON DAHLIA.**— *Calligrapha c. californica* Linell fed on the foliage of dahlia in a garden at Boswell, B.C.

**COLUMBINE INSECTS.**— Small numbers of the columbine borer were reported from Manitoba, and of a leaf miner, *Phytomyza aquilegiae* Hdy., at Marmora, Ont.

**FOUR-LINED PLANT BUG.**— Nymphs and adults of the four-lined plant bug were troublesome in a number of flower gardens and borders in the southern part of Essex County, Ont.

**GEOMETRID ON JUNIPER.**— Larvae of *Thera procteri* Brower caused slight to moderate damage to Savin juniper in Ottawa, Ont. The insect has become almost an annual pest, but recently has caused much less damage than in 1946 and 1947, when damaged shrubs winterkilled.

**GREENHOUSE WHITEFLY.**— This greenhouse pest occurred commonly in Winnipeg, Man.; was occasionally reported in New Brunswick; and in Essex County, Ont., caused moderate damage to fall tomato crops in greenhouses.

**IMPORTED CABBAGEWORM ON NASTURTIUM.**— A heavy infestation of larvae of the imported cabbageworm occurred on nasturtium in a garden near Edmonton, Alta. This was the first local record of this nature, although eggs had been observed on nasturtium elsewhere in the Province.

**LEAFHOPPERS.**— The rose leafhopper occurred commonly at Vernon, B.C., and *Erythroneura* sp., probably *ziczac* Walsh, as usual, caused moderate to severe damage to Virginia creeper, reports being received from Vernon, B.C., and Saskatoon, Dunfermline, and Scott, Sask.

**LILAC INSECTS.**— The lilac leaf miner was commonly reported wherever lilac was grown in Eastern Canada. The lilac borer, frequently reported in the Winnipeg, Man., area in 1952, was not reported in 1953.

**MITES.**— In Manitoba, the cyclamen mite was a pest in greenhouses at Winnipeg and Morden, and *Eotetranychus pacificus* (McG.) and *E. mcDanieli* (McG.) were abundant on petunia, carnation, pansy, and sweet pea throughout the Winnipeg area. In Essex County, Ont., the two-spotted mite caused severe damage in greenhouses, where poorly controlled, and mites of the two-spotted complex injured evergreens and many varieties of deciduous shrubs and flowers throughout the summer. The tomato russet mite was found on tomatoes in two greenhouses during November and December, but in neither case was injury of economic importance. The only previous outbreak of this pest on greenhouse tomatoes was recorded in the Harrow-Leamington area, Ont., in January, 1952. In New Brunswick, roses were extensively damaged by mites in the Hartland area.

**NARCISSUS BULB FLY.**— Although the weather was unusually dull and wet in southwestern British Columbia, infestation by the narcissus bulb fly in some cases reached a level of 50 per cent where control measures were inadequate. In the interior of the Province, infestation of daffodils was reported from Penticton and Vernon.

**PAINTED-LADY.**— Larvae of this insect caused minor damage to hollyhock at Maple Creek, Sask.

**ROSE INSECTS.**— Rose curculio was commonly reported in Vernon, B.C., was not reported in Saskatchewan, and was reported in small to medium numbers at Morden, Crystal City, and Brandon, Man. Wild roses also were generally infested in Manitoba. In Saskatchewan an unidentified cynipid gall was more numerous than for many years at Beadle, Pike Lake, Swift Current, and Saskatoon.

**SCALE INSECTS.**— In Saskatchewan, scale insects were reported on ferns at Englefield, on oleander at Melville, and on African violet at Moose Jaw. In Essex County, Ont., inquiries were received regarding the control of oystershell scale, San Jose scale, terrapin scale, and rose scale during the summer. Oystershell scale occurred fairly commonly on fruit trees and ornamentals in extreme southwestern Ontario and was observed in severe infestation numbers in an area near Cedar Springs. Juniper scale was common on many species and varieties of ornamental juniper in Ontario. Considerable injury occurred on certain varieties, but others appeared to tolerate moderate infestations. *Aspidiotus nerii* Bouché was reported attacking English ivy at St. John, N.B.

**THRIPS.**— The gladiolus thrips was prevalent in Manitoba, in many cases invading gardens from neighbouring lots where corms had not been treated for thrips. Onion thrips occurred on cucumber in several greenhouses in Essex County, Ont., during March and April.

#### INSECTS ATTACKING MAN AND LIVESTOCK

**A BAT BUG.**— An outbreak of *Cimex pilosellus* (Horv.) was observed in a poultry house and in a barn at Riviere-Ouelle, Kamouraska County, Que., and specimens were received from Brockville, Ont.

**BED BUG.**— Single infestations were recorded from New Westminster and Lumby, B.C.; one from Lethbridge, Alta.; one each from Jasmin and Mervin, and three from Saskatoon, Sask.; one from Brandon, Man.; one each from New Lowell, London, and Warren, and five from Ottawa, Ont.; and one from Gatineau Mills, Que.

**BLACK FLIES.**— An infestation of *Simulium arcticum* Mall. in an area confined to a small valley near the Monashee Pass, B.C., was severe in 1951 and 1952. Control measures were applied in 1953 and the pest was of negligible proportions. Black flies continued to be a pest at Mt. Seymour Park, near Vancouver. In Saskatchewan, an outbreak in June of *S. arcticum*, from the Saskatchewan River near Prince Albert, killed two bulls and injured other livestock. Elsewhere this species was not abundant. Minor outbreaks of *S. meridionale* Riley from the South Saskatchewan and Red Deer rivers in late August alarmed some livestock owners, but no damage was reported. *S. vittatum* Zett. was locally abundant early in the spring near a few streams in central Saskatchewan, and late in the summer near irrigation drainage ditches in southern Alberta. In the Souris River, Man., a moderate infestation of larvae of *Simulium venustum* Say occurred in the Melita area and a heavy infestation at Buncloody. Adults emerged at two periods, as a result of an intervening cold spell that delayed larval development. Good control of the later hatch was obtained by the use of DDT, but some of the early-maturing larvae pupated before control measures were applied. *Simulium* spp. were a serious pest of livestock and man in Hastings County, Ont., during a short period in May; flight terminated abruptly, however, except in certain districts where conditions were exceptional. In the Cordova, Ont., area, older residents described the flight as the greatest in memory. In Newfoundland black fly populations were reported to be larger than in 1952 and of major importance.

**BLACK WIDOW SPIDER.**— Although this species was common in the interior of British Columbia, and a source of considerable concern to many, no reports of bites were received. In Saskatchewan a single report was received from Artland.

**BLOW FLIES AND FLESH FLIES.**— In British Columbia, larvae of *Sarcophaga citellivora* Shew. caused myiasis in kittens and infested ground squirrels, and *Wohlfahrtia* sp. infested a puppy, at Kamloops. Species of the latter genus also infested a baby at Penticton, and a baby and a litter of very young puppies at Vernon. A severe outbreak of myiasis in sheep, probably caused by *Phormia regina* (Mg.), occurred in the Agassiz area. In northern Alberta four cases of infant myiasis caused by *Wohlfahrtia opaca* (Coq.) were reported from the Picture Butte area. Infestation of a kitten was also reported. In Ontario, a case of skin infestation in an infant by larvae of *Wohlfahrtia vigil* (Walk.) was reported from Ottawa. Boil-like lesions occurred on the face, arms, and chest in all cases of infant infestation reported. In Newfoundland, an estimated 20 per cent of the sheep population in the Bell Island and Conception Bay areas were affected by cutaneous myiasis, believed to have been caused by the English sheep-wool maggot, *Phaenicia sericata* (Mg.). Some mortality resulted from the infestation, which was the first recorded in the Province.

**CATTLE GRUBS.**— On the basis of samples of 30 calves taken from two herds in the Kamloops, B.C., district, an average of 29.7 larvae of the common cattle grub per animal emerged from the backs. A natural mortality of 48.4 per cent occurred before emergence. This compares favourably with an average of 34.7 grubs per animal emerging in 1952, and with the average of 34.9 grubs per animal emerging from 1947 to 1952. The average number of larvae of the northern cattle grub emerging from the same samples was 3.5 per animal. No earlier figures were available for comparison. In Manitoba, some 288,000 cattle were treated for control of cattle grubs. A case of human myiasis caused by *Hypoderma* sp. in a child was reported during late winter from northern Alberta.

**CHORIOPTIC MANGE.**— Infestations of chorioptic mange were reported in cattle herds as follows: Alberta, 1; Manitoba, 4; Ontario, 8; Quebec, 1; New Brunswick, 2; Nova Scotia, 1.

**FLEAS.**— In British Columbia, many inquiries regarding infestations of *Ctenocephalides* spp., on cats and dogs, were received at Vancouver. An outbreak of these species occurred in a new residential area near Edmonton, Alta., reports indicating that the fleas were developing in sand and gravel on freshly surfaced roads. Infestations in Ontario were reported as follows: Ottawa, 26; Simcoe, 1; Port Hope, 1; Sarnia, 1. Chicken fleas, *Ceratophyllus* sp., were reported attacking humans on several occasions in northern Alberta, and at Marchwell, Sask., caused annoyance to children.



**HORN FLY.**— This livestock pest persisted in normal numbers throughout most areas of Canada. In northern Alberta the severe outbreak of 1951 subsided entirely.

**LICE.**— Cattle lice were fairly commonly reported. The crab louse was reported from Saskatoon, Sask., and Ottawa, Ont., and *Goniodes pavonis* (L.) occurred on peacocks in Assiniboine Park, Winnipeg, Man.

**MITES.**— The chicken mite was commonly reported. The northern fowl mite infested poultry at Neepawa and Charleswood, Man., and bird mites, probably Dermanyssidae, forced the inhabitants from a dwelling at Glidden, Sask., and caused a severe skin rash on a woman at Ottawa, Ont. Both infestations originated in birds' nests. Bird mites were also reported to be common household pests in Vancouver, B.C.

**MOSQUITOES.**— In southwestern British Columbia, *Aedes* spp. of snowpool origin were much reduced in numbers, after a winter of abnormally light snowfall. For the same reason, spring flood levels were much lower than usual and in most flood-water regions species were of average importance or less. For the first time in its history, the City of Edmonton, Alta., undertook an extensive mosquito control campaign. Weather conditions hampered operations and, though nearly 100 per cent mortality was obtained in treated waters, mosquitoes were locally abundant during June. Exceptionally heavy rains during the latter half of July caused extensive flooding and an abnormally large hatch of eggs, particularly of *Aedes vexans* (Mg.). In consequence, mosquitoes were believed to have been more abundant during August than they had ever been at any season of the year. Mosquitoes were again abundant over the entire agricultural area of Saskatchewan, although emergence was later than average. Species causing greatest concern in the southern half of the area were *Aedes spencerii* (Theo.), *A. campestris* D. & K., *A. flavescens* (Müller), *A. dorsalis* (Mg.), and *A. vexans* (Mg.). *A. dorsalis* and *A. vexans* were prevalent as late as August as a result of rains in late summer. The northern portion of the agricultural area was pestered by *Aedes flavescens*, *A. campestris*, *A. cinereus* Mg., *A. fitchii* (F. & Y.), and *A. excrucians* (Walk.). Adults and larvae of *Culiseta inornata* (Will.) were more numerous than usual in the Saskatoon, Regina, and Swift Current areas. Adults of *Anopheles earlei* Vargas appeared to be more abundant than usual in the Pike Lake district, causing considerable annoyance to man and livestock in very early spring, and residents reported that they had been bitten periodically by this mosquito throughout the winter. This species was also taken at North Battleford and Prince Albert during the latter half of April. In Manitoba, too, mosquitoes, chiefly *A. spencerii*, *A. vexans*, and *A. dorsalis*, were unusually abundant and troublesome because of heavy rains and large amounts of stagnant water. In Ontario, mosquito populations were the largest in several years in southwestern districts, and persisted in eastern areas during most of the summer. The presence of predacious mosquito larvae, *Chaoborus* sp., in the Chatham water supply caused some concern in October. No severe outbreaks were reported from the more easterly areas of Canada.

**STABLE FLY.**— This irritating pest of man and livestock was commonly observed in Manitoba, and particularly abundant in resort areas along Lake Erie, Ont.

**TABANIDS.**— Populations of *Tabanus* spp. and *Chrysops* spp. were more or less normal in Saskatchewan and in the St. Lawrence Gulf provinces. In Ontario they were considerably reduced from their numbers in 1952 in extreme southwestern areas, but were very numerous in eastern areas.

**TICKS.**— *Dermacentor andersoni* Stiles, in the free-living stage on grasses, was considerably more numerous than in 1952 in British Columbia. New sites of high concentration were found in the Stump Lake area, south of Kamloops. The infestations at Rayleigh, north of Kamloops, remained low, whereas they had been high until 1952. Despite the increase in active tick populations, fewer cases of infestation and paralysis of cattle and sheep were reported than in 1952. This may have been a result of warm, dry weather. Several cases of infestation of children, including two of paralysis, were reported at Kamloops. One death resulted when a young girl became infested near Vernon, and the resulting paralysis was mistakenly diagnosed as poliomyelitis on her return to her home at Edmonton, Alta. Increased numbers of *D. andersoni* were

reported from Elbow, Sask. Larval populations of *Dermacentor albipictus* (Pack.) remained high in the southern Cariboo, B.C. Surveys between Clinton and Williams Lake showed larger populations than in the Kamloops district. Despite clement winter and spring weather, heavily infested dead moose were reported from the district, with particularly high concentrations in the Prince George district about 100 miles north of the surveyed area. Casual examination of deer from the North Thompson, B.C., area, in 1952, revealed only one animal infested with the spinose ear tick, *Otobius megnini* (Dugès). A survey in 1951 had revealed 15 per cent infestation. None were found in 1953. A lack of reports indicated that *Ixodes pacificus* C. & K. was scarce in residential areas of southwestern British Columbia. *Dermacentor variabilis* (Say) occurred commonly in Manitoba. Two reports of tick infestations on dogs were received from the Ottawa, Ont., area.

WASPS.—Wasps were particularly abundant in the Okanagan Valley, B.C., and in northern Alberta. In Saskatchewan reports were scarce. *Vespula maculata* (L.) and *Vespula* spp. were common in Manitoba, the former being observed feeding extensively on adult tabanids at Wanless. Complaints of nests about dwellings and wasps in buildings and playgrounds were numerous in the Ottawa, Ont., area. A slight increase in populations of *Vespula vulgaris* (L.) was reported from Newfoundland.

#### HOUSEHOLD INSECTS

ANTS.— Of the various ant species reported, carpenter ants, *Camponotus* spp., continued to be by far the greatest offenders as pests of houses and other building structures from coast to coast. Some 60 complaints, mainly of local origin, were received at Ottawa; and at Chatham, Ont., at least 50 per cent of all reports of ant infestations referred to carpenter ants. The pharaoh ant occurred in a severe outbreak in a military hospital at Vancouver, B.C., and was commonly reported in Ontario, Quebec, and Prince Edward Island. Large numbers of *Formica obscuripes* Forel invaded colonies of bees at Langruth, Man., and fed on the honey. *Lasius niger neoniger* Emery occurred in the studding of a Vancouver, B.C., dwelling. Specimens of *Crematogaster lineolata* Say were received from Owen Sound, Ont. The thief ant was recorded at Ottawa, Ont., and throughout the country innumerable infestations, not identified as to species, occurred in buildings, lawns, gardens, and golf courses.

BAGWORMS.— Specimens of *Solenobia* sp. were received from a Toronto resident who had found them in some numbers on windows. The insect normally lives on the bark of trees.

BOOKLOUSE.— *Liposcelis divinatorius* (Müll.) was occasionally reported in dwellings at Vancouver, B.C., and Ottawa, Ont., and was more abundant than usual, especially in new homes, in northern Alberta.

BOXELDER BUG.— Invasion of dwellings by this insect was commonly reported during late fall and early spring in British Columbia. The insect was more abundant than for many years in Saskatchewan, mainly in central and west-central districts. Several reports were received in Manitoba, and many reports in Ontario, chiefly in southwestern areas.

CARPET BEETLES.— Recent records on carpet beetles in British Columbia revealed that the varied carpet beetle is not only by far the most prevalent species in the southern part of the Province but the most important household pest as well. Elsewhere in Canada it has been only occasionally recorded. The black carpet beetle, as usual, was a serious pest throughout the country. It was moderately common in British Columbia, but in northern Alberta was reported as having almost replaced the clothes moth as a pest of fabrics. Records were numerous and general in Saskatchewan, Manitoba, and Eastern Canada, where, as in Alberta, it was believed to have surpassed clothes moths as a household pest. *Anthrenus scrophulariæ* (L.), moderately common in most of Eastern Canada, was fairly numerous in Prince Edward Island.

CLOTHES MOTHS.— Reports of fabric damage by clothes moths were outnumbered by those of carpet beetles by about five to one at Vancouver, B.C., and Ottawa, Ont. The webbing and casemaking species were both commonly reported, the latter outnumbering the former two to one at Vancouver, B.C.

**CLUSTER FLY.**— Hibernating adults were commonly reported in British Columbia and Ontario. None were reported from the Prairie Provinces and records from the St. Lawrence Gulf provinces were scarce.

**COCKROACHES.**— The German cockroach continued to be a common pest, particularly in eating establishments throughout the country, but its importance has waned somewhat in recent years with the introduction of more specific insecticides. *Parcoblatta pennsylvanica* (Deg.) occurred fairly commonly in cabins and summer cottages throughout many rocky, lightly wooded areas of Ontario and Quebec. The oriental cockroach was recorded from Toronto and Ottawa, Ont., and St. John's, Nfld.

**CRICKETS.**— A few infestations of the house cricket were reported in Ontario, one in a large apartment building at Ottawa being rather severe. Camel crickets, *Ceuthophilus* sp., were frequently reported in basements of new dwellings in Alberta, and occurred commonly in basements of dwellings in the Ottawa Valley.

**CURCULIONIDS.**— The strawberry root weevil was commonly reported as a household pest from Alberta eastward. The black vine weevil occurred in some numbers in a dwelling at Ganonoque, Ont.

**FRUIT FLIES.**— A severe infestation of *Drosophila repleta* Woll. occurred in a large, modern cafeteria in Ottawa, an exhaustive search failing to reveal the breeding source; the breeding habits of this species are not definitely known.

**HOUSE CENTIPEDE.**— Specimens of this predator were received from several buildings in Ottawa and Picton, Ont.

**HOUSE FLY.**— Larger populations and increasing difficulty in control were reported from some sections of British Columbia, most areas of Ontario, and many areas of Quebec. Average or below-average numbers were reported from Saskatoon, Sask., Manitoba, Prince Edward Island, and Newfoundland.

**LADY BEETLES.**— Large numbers of hibernating adults of the two-spotted lady beetle invaded many dwellings in the Ottawa, Ont., district during the fall.

**LARDER BEETLE.**— This dermestid was reported by several residents of Ontario and Quebec. In one instance the larvae were working in Ten-Test wall board.

**MASKED HUNTER.**— Specimens were received from Ottawa, Brockville, and Trenton, Ont.

**MITES.**— The clover mite was reported to have invaded a home at Penticton, B.C.; was a common house pest in Alberta; and entered houses and other buildings in very large numbers in Swift Current, Moose Jaw, Primate, Canuck, Yorkton, and Saskatoon, Sask., and Souris and Winnipeg, Man. It was also frequently reported as a pest of buildings in Ontario and Quebec, returning periodically throughout the season to some houses in extreme southwestern Ontario.

**A MUSCID.**— Since the muscid *Musca autumnalis* Deg. was first recorded in Canada at Middleton, N.S., in 1952, a limited survey has revealed its presence in smaller numbers at Bridge-town, Kingston, Lawrencetown, Victoria Vale, Yarmouth, Kentville, and intermediate points in the Province.

**PARSNIP WEBWORM.**— Hibernating adults of this insect were reported as being a nuisance in dwellings at Ottawa and Trenton, Ont.

**A SCAVENGER BEETLE.**— *Nitidula bipunctata* (L.) occurred in some numbers in a Montreal, Que., dwelling.

**SEWAGE FLIES.**— A particularly large flight of Psychodidae occurred in April at Salmon Arm, B.C. They were attracted to street lights in countless thousands. Species of this family occasionally infest overflow outlets and drain pipes in wash basins and bath tubs.



**SILVERFISH.**— The firebrat was reported to be spreading and increasing in numbers in Vancouver, B.C. It occurred in an extensive infestation in two 15-family apartment blocks at Trenton, Ont., and was commonly reported in Quebec. *Lepisma saccharina* L. was reported from Ontario, Prince Edward Island, and Newfoundland. Unspecified infestations of Lepismidae were reported from dwellings, stores, institutions, offices, laboratories, and a cleaning plant, at various points throughout Canada.

**SPIDER BEETLES.**— *Ptinus* spp. were commonly reported in Vancouver homes and in a dwelling at Langley Prairie, B.C. *Ptinus raptor* Sturm occurred in some numbers in a dwelling in Quebec, Que.

**TENT CATERPILLARS.**— The forest tent caterpillar continued to be a nuisance on and about dwellings in the Ottawa Valley, and the native parasite *Sarcophaga aldrichi* Park. was even a greater nuisance than in 1952 in some areas, soiling washings hung out to dry and alighting on the exposed parts of workers, bathers, vacationists, and others engaged in outdoor activities.

**TERMITES.**— *Zootermopsis angusticollis* (Hagen), a rather rare non-subterranean termite, infested a pulp mill at Port Alberni, B.C., attacking practically all parts of the building. An infestation of this species had been found in 1952 in a sash and door warehouse in Vancouver. Reports of *Reticulitermes* sp. were fairly numerous in Vancouver, and a frame house was extensively damaged at Kelowna, B.C. A survey of the general area infested by *R. flavipes* (Koll.) in Toronto, Ont., revealed no new outbreaks and only slight extensions in the area previously known to be infested.

**WOOD BORERS.**— Adults of *Xylotrechus undulatus* (Say) emerged from the flooring of a house at Lumby, B.C., and were found in the flooring of a schoolhouse at Kentville, Man., the school having been built four years previously. The wharf borer occurred in the washroom of a factory at Smiths Falls, and in a plant nursery at Owen Sound, Ont., and in dwellings in Hull, Que., and Yarmouth, N.S. Adult cerambycids emerged from wood used in the construction of several new dwellings in Saskatchewan. *Pentarthrum huttoni* Woll., first reported in Canada from Quebec, Que., in 1952, was found in flooring at four other locations in the city in 1953. *Buprestis aurulenta* L. damaged flooring in a house in Vancouver, B.C. The elm borer emerged from firewood in the basement of an Ottawa, Ont., residence. *Sirex cyaneus* F. was found emerging from birch plywood panelling in a new office in Vancouver.

Powder-post beetles were commonly reported as causing extensive damage in many provinces. *Habrobregmus destructor* Fischer caused the collapse of an old house in Victoria, B.C., and was known to be infesting many others. *Stephanopachys* sp. probably *substriatus* (Payk.), was reported from Winnipeg, Man. *Dinoderus minutus* (Fab.) was found in imported bamboo stakes used in greenhouses at Toronto, Ont. Recent survey work in western areas of southern Ontario, carried out from the Ontario Agricultural College, Guelph, revealed the following species of Anobiidae and Lyctidae: *Platybregmus canadensis* Fischer, *Habrobregmus carinatus* (Say), *Ernobius mollis* (L.), *Xyletinus peltatus* (Harris), *Lyctus planicollis* Lec., *Anobium punctatum* (Deg.), *Ptilinus ruficornis* Say, and *Trypophytus sericeus* (Say).

#### STORED PRODUCT INSECTS

**STORED GRAIN INSECTS.**— The most serious stored product insect problems in Western Canada were those associated with stored grain. Some extensive infestations of the rusty grain beetle occurred in country elevators in the fall of 1952. This was followed by a series of infestations in grain stored in both country elevators and on the farms, especially in Saskatchewan and Alberta, during the winter months. With the coming of warm weather in 1953, additional reports of infestation were received, including a few in elevators at Vancouver and New Westminster, B.C., and grain mites and fungus beetles, *Cryptophagus* spp., became increasingly important. A few infestations of the saw-toothed grain beetle, the foreign grain beetle, *Anthicus floralis* (L.), Collembola, and other minor pests were reported. The situation in the fall of 1953 was greatly improved. Most farmers provided adequate storage facilities for their crops and less than five per cent was still in the field at the end of 1953. The crop was harvested under favour-

able weather conditions and almost all grain was dry when stored. Some infestations of the granary weevil, the rice weevil, and the rusty grain beetle in wheat from Eastern Canada were reported in December, 1953.

In British Columbia terminal elevators at Vancouver and New Westminster, the granary weevil was encountered most frequently, but in small numbers. In addition, in these elevators and at Victoria, the following insects were found feeding on accumulations of grain dust: the white-shouldered house moth, *Endrosis lacteella* (Schiff.); the brown house moth, *Hofmannophila pseudospretella* (Staint.); *Ptinus ocellus* Brown [= *P. tectus* auct.], *P. fur* L., *Eurostus hilleri* (Reit.), the yellow mealworm, psocids, and mites. In the Creston elevators, the granary weevil, the yellow mealworm, and the black carpet beetle were found.

**MILL AND FEED WAREHOUSE INSECTS.**— In flour mills throughout Canada, the confused flour beetle and the flat grain beetle were the most troublesome pests. Occasionally the Mediterranean flour moth was associated with them, especially in coastal areas of British Columbia. In the interior of the Province, the black carpet beetle was the most common beetle in cereal warehouses. In four warehouses on the prairies the hairy spider beetle was present in some numbers. Spider beetles were also reported as troublesome in Newfoundland. *Ptinus ocellus* Brown was the most important warehouse pest on the Pacific coast and occurred commonly in the interior of British Columbia. Infestations of the white-shouldered house moth, the brown house moth, the granary weevil, the cadelle, and the varied carpet beetle occurred in warehouses in Vancouver and other coast points, and the meal moth, at Grand Forks, Kamloops, and Kelowna, B.C. *Aphomia gularis* Zell. was reported from Vancouver and Victoria. The yellow mealworm occurred fairly commonly in the Province. In Ontario granaries, a fungus beetle, *Typhaea stercorea* (L.), caused concern to many farmers, and the granary weevil was commonly reported. The yellow mealworm was a pest in several flour mills in Quebec.

**BEAN WEEVIL.**— This bean pest was commonly reported in Quebec and New Brunswick.

**CIGARETTE BEETLE.**— Extensive infestations were reported in a tobacco warehouse at Montreal, Que., and in an organic chemistry laboratory at Ottawa, Ont. In addition, two infestations in upholstered furniture were reported in Ontario.

**CONFUSED FLOUR BEETLE.**— This insect was a pest in the malt mill of a Vancouver B.C., brewery, and was recorded from dwellings in Saskatchewan, Manitoba, and Ontario.

**DERMESTIDS.**— The larder beetle was commonly reported as a household pest from coast to coast, and the hide beetle was found on meat scraps in a New Westminster, B.C., feed warehouse, and was intercepted at Toronto, Ont., in a settler's effects from Italy. *Trogoderma* sp. occurred in pancake flour at London, Ont.

**DRUG-STORE BEETLE.**— Reports of infestations of this beetle in foods and spices in dwellings, stores, and bakeries were fairly numerous from nearly all provinces. At Arnprior, Ont., feather pillows were infested.

**A FLOUR BEETLE.**— *Tribolium destructor* Uytten. was recorded for the first time in the City at Ottawa, Ont., where it occurred in a dwelling.

**INDIAN-MEAL MOTH.**— This stored food pest was rather commonly reported, particularly in British Columbia.

**A PARASITE OF STORED PRODUCT INSECTS.**— Specimens of *Lariophagus distinguendus* (Foerst.) were collected in powdered egg white in a Toronto, Ont., processing plant. The insect is a primary parasite of several stored product insects.

**A PEA WEEVIL.**— *Callosobruchus chinensis* (L.), commonly called the cow pea weevil in some countries, was intercepted at Toronto, Ont., in household effects from Japan. It is a southern species found mainly in field peas, and occasionally in beans.

SAW-TOOTHED GRAIN BEETLE.— Infestations of this beetle in stores and kitchens were commonly reported in Western Canada and in the St. Lawrence Gulf provinces. In Ontario and Quebec it continued to be the most frequently recorded pest of food materials in such locations.

WAX MOTH.— *Galleria mellonella* (L.) occurred commonly in bee hives in Hastings County, Ont., especially where the colonies were weakened by arsenicals. In one instance heavy parasitism of the insect was observed. Specimens of the wax moth were taken also in a house at Manotick, Ont., where bees had built a nest in an unused chimney.





## PROCEEDINGS OF THE NINETIETH ANNUAL MEETING ENTOMOLOGICAL SOCIETY OF ONTARIO

The 90th Annual Meeting of the Entomological Society of Ontario was called to order by President G. F. Manson at 9:30 a.m., November 17th in Room 234, Science Building, University of Western Ontario, London, Ontario.

During the two day meetings, Dr. B. N. Smallman, Professor A. S. West, G. Wishart, and Dr. H. Martin acted as Session Chairmen, presiding over the presentation and discussion of some forty papers. At the reception and banquet held in the Jordan Room, Hotel London, on the evening of the 18th, Dr. G. E. Hall, President of the University of Western Ontario, spoke on "The Role of the Entomologist in the Modern World".

At the business meeting on the morning of November 17th, the report of the Secretary-Treasurer was read and the financial statement presented and approved.

### FINANCIAL STATEMENT Year Ending October 31, 1953

RECEIPTS	
Dues .....	\$ 575.27
Government Grant .....	300.00
Back Numbers .....	21.00
Miscellaneous (bank interest, etc.)..	40.66
	\$ 936.93

Bank Balance	
October 31, 1953 .....	\$933.31
Less cheques outstanding	
October 31, 1953 .....	17.05
	916.26
	\$1853.19

R. C. COOKE,  
C. J. PAYTON

EXPENDITURES	
Printing the Can. Ent. ....	\$ 669.15
Library .....	326.46
Bank Exchange .....	10.19
Postage .....	50.15
Miscellaneous (Stationery) .....	34.73
	\$1090.68

Less outstanding cheques	
October 31, 1953 .....	\$ 12.00
	8.98
	20.98
	\$1069.70
Bank Balance	
November 5, 1953 .....	783.49
	\$1853.19

REG. H. OZBURN,  
Secretary-Treasurer.

At the business session held at the close of the meeting of the second day the Chairman announced that the invitation extended by Dr. J. MacBain Cameron, Laboratory of Insect Pathology and R. M. Belyea, Forest Insect Laboratory, Sault Ste. Marie, had been accepted and that the 91st Annual Meeting would be held there early in November. An invitation was extended to the National Society to hold its meeting jointly with the Ontario Society at Sault Ste. Marie. The revised constitution was approved.

The following reports were presented and adopted:

### REPORT OF THE NOMINATIONS COMMITTEE

The following members are proposed as officers of the Entomological Society of Ontario for 1954:

B. N. Smallman; R. H. Ozburn; A. M. Heimpel; H. R. Boyce; W. C. Allan; G. Wishart; B. P. Beirne.

For Auditors for the same period:

R. C. Cooke, C. J. Payton — Province of Ontario Savings Bank, Guelph.

Respectfully submitted,

G. S. Walley; H. L. House; A. S. West;  
H. R. Boyce; W. E. Heming, *Chairman*.

## REPORT OF RESOLUTIONS COMMITTEE

- (1) Resolved that the Entomological Society of Ontario hereby express its appreciation to Dr. G. E. Hall, president of the University of Western Ontario, for the use of the excellent facilities provided during the 90th Annual Meeting of the Society.
- (2) Resolved that the Society express its appreciation to Dr. G. E. Hall for his very fine address on "The role of the entomologist in the modern world."
- (3) Resolved that our sincere thanks be expressed to Dr. Martin and his staff, for a most entertaining and instructive evening at the Science Service Laboratory.
- (4) Resolved that our thanks be expressed to the Programme Committee for the excellent arrangement of the programme and for its masterful handling by the chairmen.
- (5) Resolved that the Society express especial thanks to Dr. E. J. Hambleton, Mr. B. W. Flieger, Dr. H. E. Gray and Dr. A. W. A. Brown for their presentation of the symposium "Recent large-scale operations in insect control."
- (6) Resolved that the Secretary forward to Professor A. W. Baker, President of the Entomological Society of Canada, a letter expressing our best wishes for a speedy recovery from his recent illness.
- (7) Resolved that the sincere thanks of the Society be extended to Dr. A. W. A. Brown and to Dr. B. N. Smallman and others at London for their efforts on behalf of the Annual Meeting.

G. G. Dustan, J. R. Blais, H. B. Wressell,  
A. M. Heimpel, R. W. Fisher, *Chairman*.

MEMBERS AND GUESTS REGISTERED  
AT THE NINETIETH ANNUAL MEETING,  
ENTOMOLOGICAL SOCIETY OF ONTARIO, NOVEMBER 17 AND 18, 1953

Armand, J. E. ....	Picton	Cook, E. ....	Guelph
Armstrong, J. ....	London	Copeland, C. ....	Toronto
Baird, R. B. ....	Kingston	Crawford, H. G. ....	Ottawa
Baldwin, W. F. ....	Belleville	Davey, K. G. ....	London
Barlow, J. S. ....	Belleville	Davies, D. M. ....	Hamilton
Beaudoin, N. P. ....	Montreal	Doane, J. ....	Guelph
Begg, J. A. ....	Chatham	Downe, A. E. R. ....	Kingston
Bond, E. J. ....	London	Dustan, G. G. ....	Vineland Station
Boyce, H. R. ....	Harrow	Elliott, J. H. ....	Toronto
Boyce, K. E. ....	Chatham	Elliott, K. R. ....	London
Brown, A. W. A. ....	London	Fenney, G. T. A. ....	Toronto
Brown, B. ....	London	Fisher, J. C. ....	Harrow
Cameron, N. ....	Montreal	Fisher, R. W. ....	London
Carpenter, W. S. ....	Oakville	Follwell, J. A. ....	Toronto
Cass, L. M. ....	Ottawa	Foott, W. H. ....	Harrow
Chard, J. R. ....	Forest	George, J. ....	Guelph
Chefurka, W. ....	London	Goble, H. W. ....	Guelph
Chisholm, D. ....	Kentville, N.S.	Godward, J. H. ....	London

Graham, A. R. ....	Belleville	McNay, C. G. ....	Ottawa
Graves, R. E. ....	Chatham	Oakley, J. A. ....	Toronto
Gray, D. E. ....	Ottawa	O'Brien, R. D. ....	London
Guppy, J. C. ....	Ottawa	Ozburn, R. H. ....	Guelph
Haines, Robert ....	London	Pearce, D. A. ....	Montreal
Hall, J. A. ....	Simcoe	Pearse, F. S. ....	Sarnia
Hall, R. R. ....	Ottawa	Pechuman, L. L. ....	Lockport, N.Y.
Hambleton, E. J. ....	Washington, D.C.	Peterson, D. G. ....	Ottawa
Hartley, J. B. ....	London	Phillips, J. A. H. ....	Vineland Station
Heimpel, A. M. ....	Sault Ste. Marie	Randall, A. P. ....	London
Heming, W. E. ....	Guelph	Roadhouse, L. A. O. ....	Ottawa
Herne, D. ....	Guelph	Rose, A. H. ....	Sault Ste. Marie
Herron, J. C. ....	Chicago, Ill.	Ross, W. A. ....	Ottawa
Hikichi, A. ....	Simcoe	Salkeld, H. ....	Bradford
Hudson, F. J. ....	London	Sampson, R. E. ....	London
Judd, W. W. ....	London	Sanderson, D. W. ....	Toronto
Kenaga, E. ....	Midland, Mich.	Sheppard, R. W. ....	Niagara Falls
King, G. B. ....	Guelph	Shewell, G. E. ....	Ottawa
King, J. E. ....	Montreal	Short, S. H. ....	Ottawa
Kirby, C. S. ....	Sault Ste. Marie	Sillman, E. I. ....	Guelph
Lalonde, V. ....	Chatham	Smallman, B. N. ....	London
Lapp, W. R. ....	Windsor	Smith, B. C. ....	Belleville
Loschiavo, S. R. ....	Ottawa	Smith, M. V. ....	Guelph
Lougheed, A. W. ....	Elmira	Smith, S. G. ....	Sault Ste. Marie
Manson, G. F. ....	Chatham	Stearman, W. A. ....	Collingwood
Martin, H. ....	London	Stephens, J. M. ....	Kingston
Martin, J. C. ....	Belleville	Teskey, H. J. ....	Guelph
Mason, W. R. M. ....	Ottawa	Urquhart, F. A. ....	Toronto
Maybee, G. E. ....	Belleville	Walsh, R. W. ....	Harrow
Miles, J. R. W. ....	Chatham	Waterhouse, J. S. ....	Guelph
Miller, C. D. F. ....	Ottawa	West, A. S. ....	Kingston
Miller, L. A. ....	Chatham	Wetmore, F. R. ....	Windsor
Monro, H. A. U. ....	London	Wiffen, E. ....	Guelph
Monteith, L. G. ....	Belleville	Wiggins, G. B. ....	Toronto
Moreland, C. R. ....	Ottawa	Williams, J. ....	Bradford
McClanahan, R. J. ....	Chatham	Wolfe, L. S. ....	London
McIntyre, R. E. ....	Toronto	Worth, G. E. ....	Montreal
McKercher, J. T. ....	London	Wressell, H. B. ....	Chatham
McLeod, W. S. ....	Ottawa	Wylie, H. G. ....	Belleville

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